COLORADO IRON WORKS COMPANY

ORE SMELTING EQUIPMENTS

ORE MILLING MACHINERY

CATALOGUE 12-F

SOME DETAILS as to SMELTING PRACTICE and EQUIPMENTS

14-8863

1860 1914

DENVER, COLORADO.

U.S.A.

ESTABLISHED 1860

Catalogue No. 12-F

Some Details as to Smelting Practice and Equipments

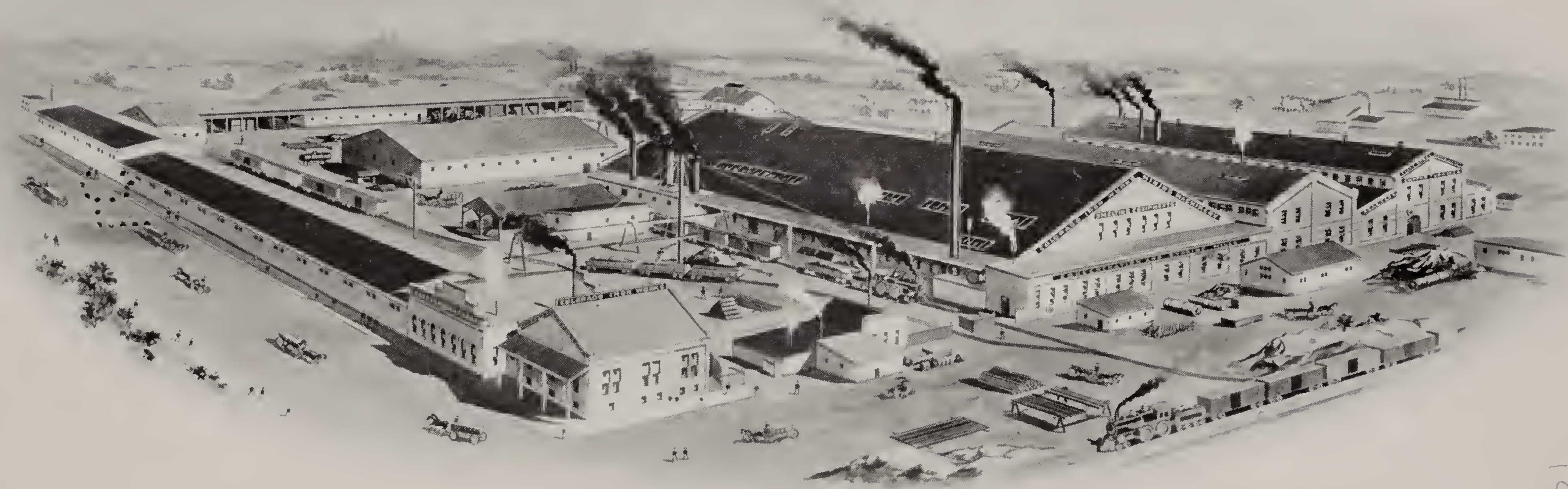
The Metallurgical Principles which Underlie,
and the Apparatus which Accomplishes the Recovery of
Lead, Copper, Gold and Silver from their
Ores by Fire Methods

Colorado Iron Works Co.

Denver, Colorado, U. S. A.

Private Exchange Telephone Main 3380

Cable Address: "NESMITH, DENVER." Codes: Lieber's, Bedford McNeill's,
Moreing & Neal's, A. B. C. (fifth edition), Western Union, Directory



PLANT OF COLORADO IRON WORKS COMPANY, DENVER, COLORADO.

ANNOUNCEMENT.

We issue separate catalogues of the machinery and apparatus which we manufacture for use in the treatment of ores by amalgamation, concentration, cyanidation and smelting. This one is devoted to smelting, and is designed to illustrate and describe a sufficiently wide variety of our productions to acquaint our friends and the public with the nature of our line, and to be useful in the discussion of matters between them and ourselves.

It has become a settled practice with us to preface each of our catalogues with a description of the process to which it is devoted, and these, though necessarily brief, are accurate so far as they go and they are thought to go far enough for the purpose. Those expecting to embark in smelting will, if they be without previous experience, find in the article in this catalogue just what they need to inform them of the fundamentals necessary to an understanding of the subject, and if disposed to go exhaustively into the details of it, they will have lost nothing by the preparation they here receive for the standard textbooks.

It is always difficult in the preparation of our catalogues to place a limit on their size and at the same time show the more important portion of our line. From the present edition of our smelter catalogue much is omitted which might be presented, due to its being crowded out by new, and what has been regarded more important matter. The failure to find anything in the smelting line which is sought among its pages should therefore not be taken as an indication that we are not prepared to supply it.

We design and equip plants for the reduction of ores by all modern processes and in addition we will engage to erect them complete, demonstrating their efficiency in practical operation.

We endeavor to have our illustrations correctly represent the various machinery, but in the advance which is continually being made in efforts to improve it, changes in detail are made from time to time. As these are in the interest of the purchaser, we feel that an apology on this account is perhaps superfluous.

Our aim has always been the production of a high-grade line of machinery, the prices being made as low as consistent with high quality. In no case do we attempt to build a machine to come within a certain price and place it in the field of competition with others having low first cost as their chief merit. It is this policy, consistently maintained for fifty years, that has established our enviable reputation.

COLORADO IRON WORKS COMPANY.

REPAIR WORK.

We desire to call particular attention to the promptness with which repairs and renewals can be made at our works. Our foundry and machine shops are ample and no delays need be anticipated.

Our advantages are apparent to our smelting friends in the Rocky Mountains, as from three to fourteen days are saved in procuring supplies from Denver direct. We have telephone connection with nearly all mining camps in Colorado and adjoining States, and preference is always given renewal orders, as we fully realize the importance of keeping a plant running.

In ordering repairs be very specific and give numbers where possible. Make measurements carefully, and when possible give a rough sketch, no matter how crude. Where practicable refer to catalogue number for details, etc.

TERMS.

Our terms to regular customers with established credit are monthly settlements. On new business, for equipment only, one-third to one-half cash with order, balance when ready for shipment. On new business, for equipment and erection, one-third to one-half cash with order with special arrangements as to payment of the balance. On special work done to order, cash in advance or part cash in advance and an ample guarantee to secure payment of the balance.

Remittances should be in Denver or New York funds or their equivalent. We pay no exchange.

SHIPPING DIRECTIONS.

Shipping directions should be explicit and state whether by freight or express. If not otherwise instructed, all material will be shipped by freight, except light packages, which will be forwarded by express.

Our responsibility ceases with delivery to the carrier in good order. In the event of loss or damage in transit, the agent of the carrier should be immediately notified. We will render all assistance possible in adjusting the claims of our customers for losses, damage and excess charges.

PREFACE.

On the following pages we present short descriptions of lead and copper smelting, in which we aim to furnish sufficient information to those without previous knowledge of the process, to enable them to understand the underlying principles, and to render a discussion of smelting intelligible to them. A further purpose is to dispel the far too prevalent belief that smelting is an intricate process and not generally available by reason of extreme complication. The reverse is actually the case. In former years an air of mystery was undoubtedly cast about the subject, the effect of which still persists to a certain extent, but as a matter of fact it is no more difficult of application than many wet extraction methods and offers the advantage that results can be foretold from analyses of the ores with an exactness not approached by tests of any wet methods. The product of smelting is nearer the finished product than is the product of many other processes, the cost of plant no greater, and smelting in many cases is the most economical. The use of the smelting process has to some extent been restricted to ores which could not be treated by any other process. This is a grave mistake, as the smelting process should with rare exceptions be used wherever it will apply.

To accomplish our purpose within the space here available, we have been obliged to confine ourselves to fundamentals and to omit much which although interesting is not essential to a general understanding of the subject. Those experienced in smelting operations, therefore, need not expect to find anything new, and others, if they desire to pursue the subject further, may do so in the various works devoted to it. In the chapters on "Hot Blast" and on "Vaporization of Jacket Water", however, we present the advantages of two systems to which we have given much study, and the advantages of which we feel are not appreciated as they should be, mainly because they have not as a rule been properly presented. The reading of these chapters by experienced smelter operators is, therefore, especially solicited.

In the introductory chapter we have endeavored to accomplish our purpose without assuming a knowledge of chemistry on the part of the reader, and while this precludes the use of formulae in explaining the reactions which take place, they are not here so necessary as in the treatment of the subject in a more exhaustive manner.

The Smelting Process.

Smelting in the broadest sense was practised in pre-historic times, but as this article is not intended to be a history of the process, but an elementary description of existing practice, we will proceed to a consideration of the reactions which take place in copper and in lead smelting with special attention to the blast furnace, owing to its more general application and wider use.

Blast furnace smelting of copper and lead ores has been brought to its highest state of development in America, and the method as now practised may be said to have come into use by successive improvements instituted within the past thirty years.

What contributed more than anything else to place smelting on its present firm foundation was the application of chemical control to the operations in place of the hap-hazard methods of earlier years. The chemical reactions taking place in smelting and the factors influencing economical work are now well understood, with the result that the availability of the process for a given ore can be predicted with certainty and the operation of smelting so conducted that the most economical work can be carried on.

To those without knowledge of the principles underlying the smelting process, the saving of the gold and silver of an ore is the feature of greatest interest. The applicability of the process depends, however, not on the metals, but on the gangue, and we will proceed to a short description of what takes place in the blast furnace, with a view to making this matter clear.

Slag Formation.

The elements entering into the composition of ores are either acid-forming or base-forming elements, and slags are compounds of acids and bases formed under the conditions prevailing in the furnace when proper relative quantities of acids and bases are present. The most common substance of a composition analogous to slag is glass. Ordinary window glass, for example, is formed by the fusion in pots of a mixture of quartz sand, soda and lime. The transparency and colorlessness of glass is secured mainly by the choice of the ingredients and their purity, and as these qualities have no importance in slags, the latter are black, or nearly so, from the oxides of the heavy metals which form a part of them. The luster of slags

varies from glassy to stony on fracture when cold, the appearance when hot also varies considerably and these physical signs mean much to experienced blast furnace men, but a discussion of them would be out of place here.

The one great acid constituent of slags is silica and the principal basic constituents are iron oxide and lime, with minor amounts of other bases, among which the principal are magnesium and manganese. None of the ordinary ore constituents by itself is fusible at smelting temperature, but the slags formed by their combination with each other are fusible and it is owing to this circumstance that the smelting process is practicable. If, therefore, a proper mixture of silica, iron oxide and lime is placed in a blast furnace, together with fuel for the production of the necessary heat and air for the combustion of the fuel is applied in the form of blast, the iron oxide and lime will combine with the silica, forming an iron and lime silicate which will melt and flow away from the remaining solid portion of the charge, leaving fresh portions to come in contact with each other and combine, and the process will be continuous if the charge and fuel are replenished and the molten slag withdrawn. This is the reaction which makes smelting possible, and while it is actually somewhat more complicated than as just described and is accompanied by other reactions of which subsequent mention will be made, it is the fundamental conception, which kept in mind, will make smelting processes easily understood.

If there were no other purpose than mere melting, the quantity of fuel used would be the amount required for the production of the necessary heat, and the amount of air supplied by the blast would be that sufficient for the combustion of the fuel. The air would be supplied at such a rate as would cause the combustion to take place with the necessary violence to maintain the required temperature. How the quantities of fuel and blast are influenced by the results desired to be obtained will appear as we proceed.

Fortunately for the practical usefulness of the smelting process, there is considerable latitude in the proportions in which silica will combine with bases to form slags, and in practice such a slag is therefore made as will produce the best net result in view of all the conditions. Distinct conceptions must be retained of two characteristics of every slag and these are the formation temperature and the melting temperature. Silica and iron oxide not only will not

combine at ordinary temperatures, but on raising the temperature they will not combine until a certain point is reached. This point is the formation temperature of the slag and consequently the smelting operation can not proceed unless the temperature within the furnace is sufficiently high to cause the formation of the slag due to the ore mixture.

To be considered apart from the formation temperature of a slag is its melting point. This is the temperature at which a slag melts and the temperature within the furnace must be sufficiently high to keep the slag in a fluid condition so that it will flow from the tap hole. Although the formation temperature and melting temperature are relatively close together they are not the same and two different conditions arise on this account. Where the formation temperature of the slag is above its melting point we have a condition in which it can be readily tapped from the furnace, but where the melting point is higher than the formation temperature, slag will form and remain in a viscous state and will not flow without the application of more heat. In the one case we have a safe slag and in the other a slag with which there is constant danger of freezing up the furnace. To be adapted to smelting, an ore must consequently contain silica, iron and lime in such proportions as will make a suitable slag, or if deficient in any of them, other ores or fluxes must be added. Detrimental compounds, as of zinc and aluminum are sometimes present, and if in large quantity they will cause trouble. For this reason it is necessary that their amount be determined, if present, and that they be considered in deciding the feasibility of smelting.

Copper Matte Smelting.

Assuming in addition to a properly proportioned mixture of silica, iron oxide and lime, a certain amount of a copper sulphide mineral, chalcopyrite, the slag will form as already described and, neglecting for the moment any action of the blast and fuel other than the production of heat, the chalcopyrite will melt and trickle down through the charge to the hearth of the furnace. On the hearth of the furnace the melted chalcopyrite, now a copper-iron matte, will sink into the molten slag by reason of its greater specific gravity and collect in a separate layer, much as oil and water separate when mixed and then allowed to stand. With tap holes at two levels, the matte can be drawn from one and the slag from the

other, but it is customary to let both slag and matte flow together into an outside settler or forehearth where they can separate undisturbed by such unfavorable conditions as exist within the furnace.

Copper matte is a mixture of copper sulphide and iron sulphide in variable proportions, together with an admixture of impurities among which are the gold and silver of the ore. It has a very strong affinity for the precious metals and will collect practically all of the gold and 95 per cent. or more of the silver, and it is, therefore, only necessary to consider the slag and the matte.

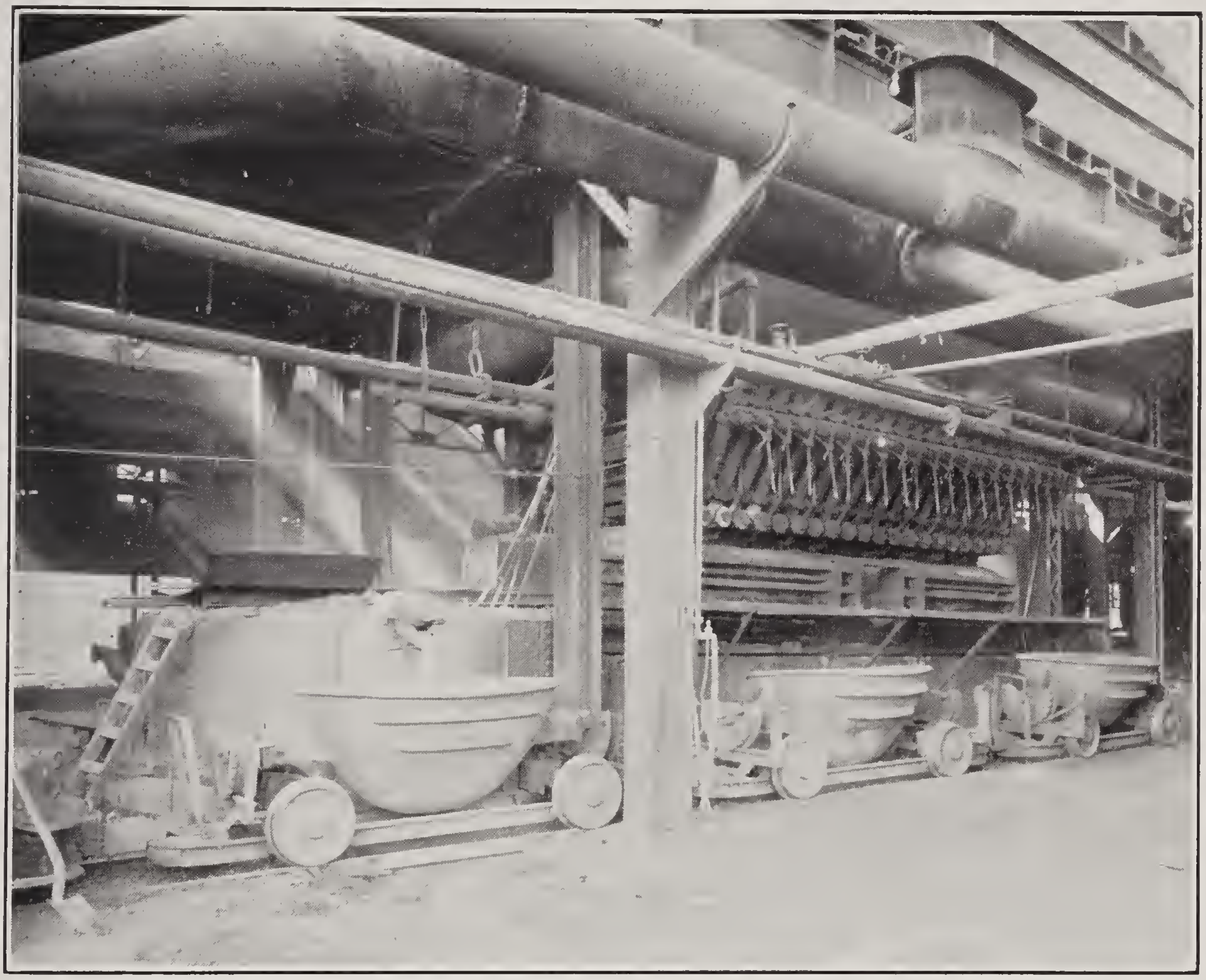


FIG. 1. INTERIOR OF A LARGE COPPER SMELTER IN ARIZONA.

In the simple illustration of matte formation just given, it was assumed that the iron and copper sulphides would melt down without change. This is not true nor is it desirable that they should do so. Both iron and copper have a strong affinity for sulphur, but a stronger affinity for oxygen, and at the temperature prevailing in the blast furnace both iron and copper sulphides are rapidly converted into oxides through the burning of their contained sulphur in the oxygen of the air blast. In addition to the combustion of sulphur a part of the sulphur of the iron sulphide is so loosely bound to the

metal that it is driven off by the mere heating to which the ore is subjected in the upper zones of the furnace, about one-half of the sulphur of pyrite being thus eliminated. Copper has a greater affinity for sulphur than iron and in consequence of this the copper will remain in combination with part of the sulphur which has not been burned off and iron will continue in combination with such remaining portion of the sulphur as is not required to satisfy the affinity of the copper. Thus, the net result is that sulphur is lost by the iron sulphide and the matte resulting from the smelting is increased in its percentage of copper. The gold and silver collected from the ore by the molten sulphides remain with the copper throughout, and the concentration of the copper in the matte by the burning off of sulphur is accompanied by a corresponding concentration of the gold and silver.

The oxygen which enters the furnace in the blast partly goes to burn the fuel. The iron sulphide is partially burned off by remaining oxygen, the sulphur forming sulphur dioxide gas which passes off by the stack and the iron also combining with oxygen to form iron oxide in which condition it enters the slag. The degree of concentration which can thus be brought about by the burning of sulphur and iron is limited by the time during which the molten sulphide is exposed to the action of the oxygen, and this is short, being the time required in trickling down from the point where melted to the hearth of the furnace; as when it reaches the hearth it sinks below the slag which protects it from the action of the blast.

The atmosphere within the copper matting furnace is therefore an oxidizing one, that is, an excess of air is blown into the furnace over what is necessary for burning the fuel, this excess being largely consumed in the oxidation of sulphur and iron. Where the percentage of sulphur in the charge is high, a great volume of blast is supplied in order to oxidize as much of it as possible and thereby produce a high grade matte. In copper matte smelting the quantity of carbonaceous fuel used is also interwoven with the amount of sulphur in the charge; the greater the amount of sulphur the less fuel is required. This is due to the fact that in the oxidation of sulphur and iron large quantities of heat are developed, indeed, furnaces running on practically pure pyrite with only enough silica to flux the iron oxidized have been kept in operation for several days without any carbonaceous fuel whatever. This is running too close

to the danger line, however, and it is customary to charge a very small amount of coke, although less than one per cent. suffices to keep the furnaces in satisfactory running order at a plant where the conditions are favorable. This is what is known as pyritic smelting.

The effect of the sulphur in the ore will now be understood in a general way. That which is not burned off clings to the copper and iron, more tenaciously to the copper than to the iron, so that the only iron in the matte is the amount necessary to satisfy the affinity of that part of the sulphur which is not required by the copper. One pound of sulphur combines with four pounds of copper, forming five pounds of copper sulphide, and one pound of sulphur combines with one and three-quarters pounds of iron, forming two and three-quarters pounds of iron sulphide. In a matte calculation, therefore, the amount of sulphur eliminated is deducted from the total sulphur in the ore, one pound of this remaining sulphur is set apart for every four pounds of copper and one and three-quarters pounds of iron for each pound of sulphur not combined with the copper. The grade of the matte, that is the ratio of concentration, depends on the amount of sulphur eliminated and it is for this reason that as much sulphur as possible is oxidized if there is an excessive amount in the ore charge. Sulphur is not always in excess, however, and in such cases what sulphur there is has to be conserved in order that a matte of too high grade be not made, as this would entail high losses of copper in the slag. The best grade of matte for treatment by converting is one containing about 45 per cent. copper and under ordinary conditions it is sought to produce a matte of about that tenor.

The above described process of slag and matte formation is all that it is really necessary to know in order to understand the general principles underlying copper matte smelting. Other elements than those mentioned are present in ores and some of them, if in large amount, call for special manipulation; but these are matters within the sphere of a competent metallurgist and their consideration here would lead us beyond the intended scope of this article.

Copper matte smelting is also carried on in reverberatory furnaces. The principles underlying this operation are the same as in blast furnace smelting, but the ore must be fine and, as there is practically no elimination of sulphur in the reverberatory, the

amount of this element in the charge must be made just sufficient to produce the desired grade of matte. Reverberatory smelting is usually restricted to concentrates which are too fine to charge into the blast furnace and, where both blast furnaces and reverberatories are in use at the same plant, the latter also receive the flue dust produced by the blast furnaces as well as other fines, thus leaving only coarse ores for the blast furnaces, thereby increasing their capacity and smoothness of operation.

The cost of smelting in reverberatories is generally considerably higher than in blast furnaces, due to the less efficient method of applying the heat, the necessity of preliminary roasting and

FIG. 2. A SMALL COPPER SMELTING PLANT IN MEXICO.

various other unfavorable features, such as increased labor and cost of maintenance. While this is true under ordinary conditions, it is but fair to state that where conducted on a very large scale with the generation of steam from the waste heat, such steam being credited to the cost of smelting, the disadvantage of the reverberatory from the standpoint of economy is a very slight one. Such results are obtained, however, in not more than five or six plants in America.

In reverberatory furnaces, the fuel is either coal or crude oil, but producer gas if sufficiently high in combustibles, gives results as good as or better than coal, as with coal there is considerable un-

avoidable loss of heat in firing and removing clinkers from the grate. It must not be understood from this that gas producers are without their drawbacks or are applicable in all cases. The fuel should be suitable for gas producer use. Wood has been used direct with some success, but is not to be considered if coal or oil is available. Whatever the fuel, the temperature which must be obtained is so high that a very strong draft and intense combustion must be continuously maintained. The coal is burned in a fire-box at one end of the furnace and a very deep bed is carried on the grates, the fire-box is thus essentially a gas producer and additional air to complete the combustion is admitted at the bridge wall. Neither coke nor charcoal is suitable and the coal should be of the long flame, "fat" variety.

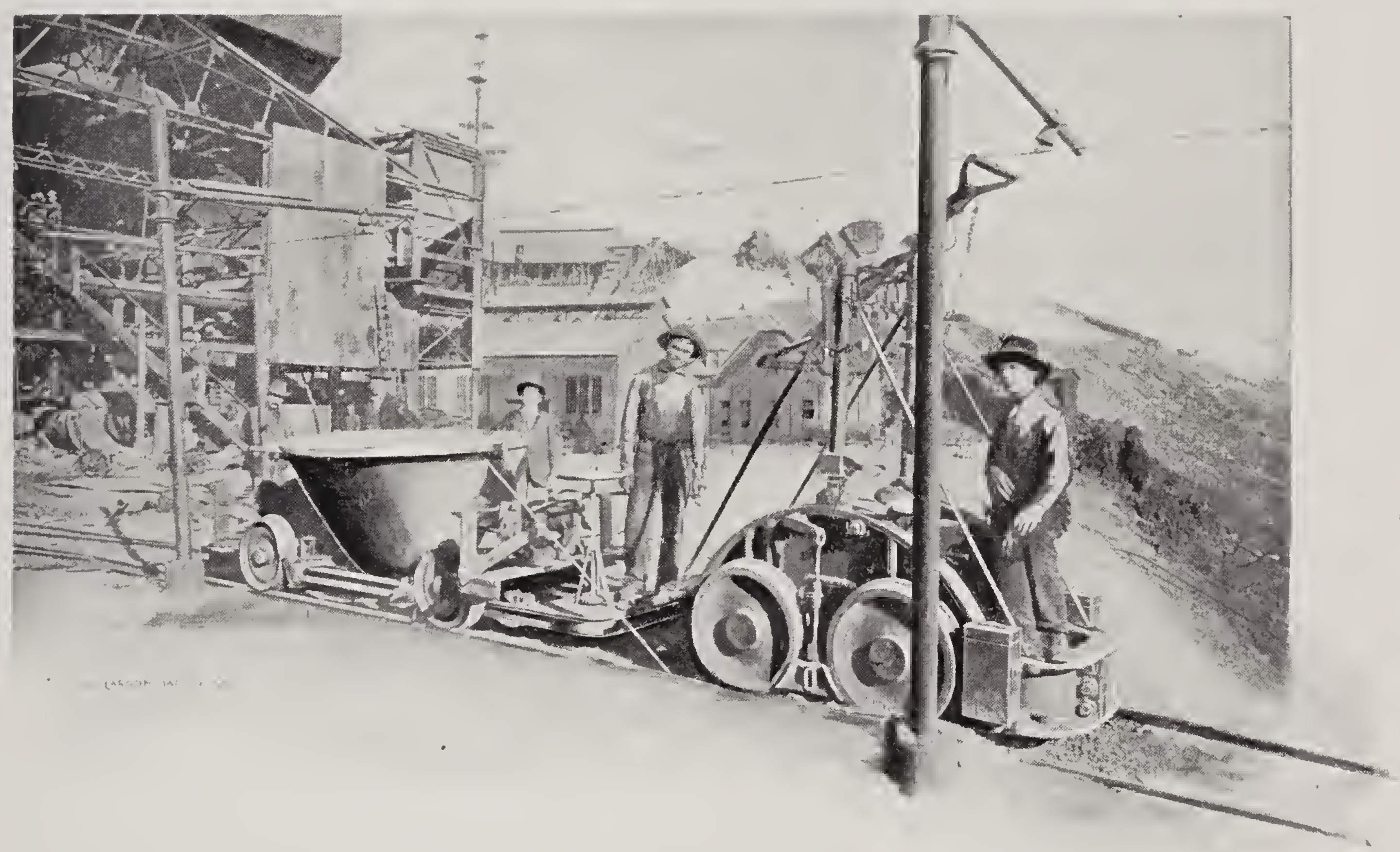


FIG. 3. SLAG DISPOSAL AT A LARGE ARIZONA COPPER SMELTER.

Crude petroleum and the cheap by-products of its distillation are used with very great success in reverberatory smelting furnaces. With oil fuel there is no difficulty in maintaining the desired temperature and in getting the heat where wanted. The furnace is not exposed to the unavoidable admission of cold air as is the case when firing and cleaning grates in furnaces using solid fuel.

Copper matte is the shipping product from smelters of moderate size as the concentration attained in the smelting reduces the

quantity of material to be handled to a point where its further treatment on the ground would not be economical. It is only at large plants that the matte is converted to metallic copper and it is ordinarily carried only to blister copper, the impure product formed by blowing air through the molten matte in converters. In remote localities where freight rates are abnormally high it may be advisable to add a converting plant operating on a scale which would not be economical were the plant more favorably situated, but such conditions are rare.

In converting, the sulphur and iron are oxidized, the sulphur passing off as sulphurous acid gas and the iron oxide combining with silica which has to be supplied. As the process has been conducted in the past the silica is in the form of very highly silicious ore, crushed and tamped into place as a refractory lining for the converter, and it is upon the lining that the iron oxide draws for its silica. For commercial reasons dry silicious gold and silver ores are used for this purpose wherever obtainable, as in the process the precious metals are recovered.

At present, converting is rapidly undergoing a transition from this "acid" process to what is known as "basic" converting. Here the converter lining is formed of a strongly basic refractory, usually magnesite brick, and the silica is charged in the form of coarse silicious ore.

Where converting is practised, the blister copper is cast into moulds and shipped to a refinery. The converter slag may be added to the furnace charge for its high iron content if iron is short there, but the usual practice is to add it directly to the settler, as it is very fluid and any entrained copper readily settles out.

The refining of blister copper in America is universally by electrolysis and as the scale of operations is necessarily very large, about a dozen plants handle the entire blister copper output of the country. Electrolytic refining is conducted in vats, with copper sulphate as the electrolyte, the blister copper forms the anode, the pure copper deposits on the cathode, and the impurities, neglecting small quantities of certain of them which go into solution and gradually foul it, collect on the bottom of the vat as the "anode mud". This anode mud contains the gold and silver.

Black Copper Smelting.

When the surface ores of copper, mainly oxides, carbonates and silicates are smelted, the product is impure metallic copper, known as "black copper." The process is not practised to a great extent owing to high slag losses.

The operation here is a reducing one; that is, an excess of coke is used, the ores giving up their oxygen to the reducing atmosphere and the metal falling to the hearth in the same manner as the matte does in smelting ores high in sulphur. On the hearth, the metallic copper is protected by a layer of slag, but in trickling down through the charge from the point where it is melted it must pass through the tuyere zone, where it is momentarily exposed to oxidation, and here some of the copper which has been reduced in the upper zones of the furnace is reoxidized and enters the slag as a silicate. Thus, copper oxide enters the slag, not only by reason of incomplete reduction in the upper zones of the furnace, but also by reason of reoxidation of reduced copper in the region of the tuyeres. In addition to the copper lost in this way, some metallic copper in an extremely finely divided condition is retained in suspension by the slag and, taken together, these losses make a total which is prohibitive in many cases.

The smelting operation proceeds rapidly, the slag formation takes place in the same manner as in copper matting, except that the iron is already in an oxidized condition, and gold and silver, if present, remain with the copper. The metallic copper, being a good conductor of heat, chills easily and for this reason the furnace is built with a crucible designed to prevent excessive radiation, and the black copper is tapped directly from this crucible into moulds.

Lead Smelting.

Lead smelting differs from copper matting in that the product is metallic lead alloyed with other metals. In this respect it is analogous to black copper smelting. Smelting to metal necessitates the maintenance of a reducing atmosphere in the furnace, and sulphur elimination is thus impossible. Lead sulphide, galena, is already in the form of sulphur combination highest in lead, and if smelted in an oxidizing atmosphere as in copper matting, the galena would mostly melt down unchanged, as but little sulphur would be eliminated by the bessemerizing action to which it would be subjected, and although a concentration would be effected, the product

would be an undesirable one. A result which would be fatal to such smelting as a profitable enterprise would be caused by the fact that such lead as was freed from sulphur would either be volatilized and pass off by the stack, carrying precious metals with it, or enter the slag as lead silicate.

Thus we have as the first requisite, a reducing atmosphere within the furnace, and as the second, a low sulphur content of the charge. The surface ores of lead are smelted raw, as they are practically free from sulphur, but as depth is gained sulphur appears and the

FIG. 4. A LARGE CUSTOM LEAD SMELTER IN WESTERN COLORADO.

ores must be roasted preliminary to smelting. At custom plants galena ores are sometimes smelted raw when the silver content is high, to avoid volatilization losses in roasting, but as the other ores in the charge must be more completely roasted to keep down the percentage of sulphur in the ore mixture, this is not strictly an exception to the above rule.

The roasting of lead ores is an expensive operation, the cost increasing greatly as the last remaining sulphur is sought to be eliminated. However, if some copper is present in the charge it

permits higher sulphur to be carried than would otherwise be possible, thus reducing the expense of roasting. For this reason all lead smelters now endeavor to carry a small percentage of copper in the charge, and in addition to base bullion, a certain amount of matte is produced. This matte is composed of the sulphides of copper, lead and iron, and besides taking care of a moderate amount of sulphur, it assists in reducing slag losses.

The matte is crushed and roasted, almost universally in hand rabbled reverberatory furnaces, and when sufficient has accumulated

FIG. 5. A LARGE LEAD SMELTING PLANT IN MISSOURI.

it is concentrated to a shipping product. Sometimes a small copper-matting furnace is used for this special purpose, but usually, in plants operating a number of furnaces, one of the lead stacks, the one which is in the poorest condition, is put on a matte charge to work up this product.

The lead smelter has not so wide a latitude in the character of the slags he can run as the copper matte smelter has. He must adhere rather closely to certain type slags which experience has shown to be suitable in order to keep the slag losses low. In blast

furnace smelting to lead base bullion, when smelting for gold and silver, which is the class of lead smelting most generally practised in America, the slags contain from 0.75 per cent. to 1.50 per cent. lead. The silver in the slag will run below one ounce per ton, but will exceed this if the bullion values are very high, say over 300 ounces per ton. Lead slags can be made much cleaner than this but the present tendency is to rapid driving, the additional tonnage put through more than compensating for the additional losses. Gold is all recovered in the bullion, and custom smelters, as a rule, actually

FIG. 6. A LARGE CUSTOM LEAD SMELTER IN EASTERN COLORADO.

show a plus gold recovery, but this is due to traces and small amounts in various ores, which are not paid for.

Zinc is objectionable in lead smelting from its causing loss of silver by volatilization with it, but only part of the zinc is volatilized and if in considerable quantity it greatly disturbs the operation of the furnace by the formaton of accretions and by reducing the fluidity of the slag. Especially will zinc cause trouble with the slag if alumina is at the same time present. Either zinc or alumina is sufficiently objectionable when alone, but when both are in the charge the difficulties are greatly increased.

Arsenic, which is mostly oxidized in the copper matting furnace, is not eliminated in the reducing atmosphere of the lead furnace, and if in considerable amount, will form speiss, which has a strong affinity for the precious metals and is a by-product difficult of treatment.

Lead furnaces are always built with a crucible in which a large body of molten lead is continually carried. The crucible is connected with a lead well exterior to the jackets by a channel, and it is from this lead well that the bullion is dipped, or allowed to flow in the case of large furnaces carrying considerable lead in the charge. Upon the lead is the matte and upon this the slag. Speiss, if made,

FIG. 7. SLAG DISPOSAL AT A LARGE COLORADO LEAD SMELTER.

forms a layer between the matte and the lead. The slag and matte, and speiss, if any, are all tapped from the furnace together, and separated in a forehearth.

Coke is the fuel of the lead blast furnace. Charcoal, if of the best, will answer where coke can not be had, but is ordinarily not to be considered as a substitute for it. In very many cases charcoal has been used to replace about half of the coke without detriment, and this may be of great advantage in some circumstances.

In Europe, lead concentrates are smelted to some extent in reverberatory furnaces. The conditions necessary to the success of this are a charge very high in lead, 70 per cent. being common, not over 4 per cent. or 5 per cent. silica, and other impurities must be present only in very small quantities. In addition to the character

of the charge, a great deal of fuel is required, the capacity is very low, and skilled labor is required.

Where galena ores are so low in silver that desilverizing the product obtained from smelting them would be unprofitable, the galena, in the form of concentrates, may be first treated in Scotch hearths, whereby about half of the lead is directly recovered, the balance being partly volatilized and partly retained in a roasted and sintered product, the gray slag. The gray slag is smelted in the blast furnace, for which it forms an ideal charge and the fume from the hearths is recovered in a bag house. The method is cheap and efficient when smelting for lead where the cost of labor is low, as preliminary roasting is dispensed with; but its use is precluded on galena containing silver owing to volatilization losses.

Except in large plants, the base bullion is shipped to a refinery where it is desilverized, almost universally by the Parkes process. This consists in adding zinc to the molten lead, mixing thoroughly, and then cooling. Before the lead solidifies, the zinc separates as a crust on the top of it and this zinc crust contains most of the precious metals. The operation is repeated, each zincing reducing the precious metal remaining in the lead, until a point is reached where the values recoverable no longer warrant their separation.

Cupellation offers advantages as a further local treatment for base bullion under certain circumstances. Conditions where it is applicable at a small or moderate size plant are insufficient lead for the blast furnace charge or very high cost of shipment on base bullion, especially if in a locality where lead is of little value. The products of the cupellation are then litharge, which is returned to the blast furnace to furnish a collector for precious metals, and a shipping product of doré bullion, which is silver bullion containing gold.

Sampling.

Automatic sampling has been developed in America to such perfection that the reliability of the work of a properly designed and equipped sampling plant is unquestioned. The underlying principles of sampling have received close study by American metallurgists with the result that the necessary conditions for accurate and concordant work have become well known.

The important features of accurate sampling are to remove a relatively large portion at each division and to recrush after each

cut, so that the size of the lumps of ore bear a proper relation to the size of the lot being sampled. To be reliable, an automatic sampling machine must remove a part of the whole stream coming to it by cutting it intermittently. Samplers which divide the stream are absolutely unreliable, as it has been found impossible to prevent concentration of values in a part of the ore stream.

Sampling plants vary in the arrangement of the equipment, and their completeness depends upon the class of ores handled; but they should in all cases conform to the principles given above. Thus a custom smelter should have and is expected to have a plant capable of very exact work, but a smelter handling ores from its own mines needs only such sampling equipment as necessary to furnish reliable data for computing the furnace charges and providing a satisfactory check on operations.

Coming to a custom plant are often dry silicious ores which are frequently spotty and difficult to sample. Accuracy here is necessary to arrive at a just settlement with the shipper. For making up furnace charges the important constituents are all present in relatively large quantities and there is not the same liability to error as in sampling gold ores where the amount of gold to be determined may be only an ounce or two in a ton. It is not intended to belittle the importance of accurate sampling at a private plant, as it is necessary if a close check is to be kept on operations. The point desired to be brought out, however, is that at a plant erected by a mining company to smelt its own ores, an elaborate sampler is not essential to the operation of the smelter, but only as a check on the work, and that a sampling plant can, therefore, be added at any time. The assays of the furnace products will show the saving and the loss, and this will suffice during the early stages of operation where it is desired to defer the expenditure of the money required for a sampler.

The illustration herewith shows the side elevation of an automatic sampling works for crushing and sampling gold ores in connection with a custom smelter. The ore is taken from the cars and shoveled into the crusher, after passing which it is elevated to the first automatic sampling machine which removes one-fifth of the bulk as a sample, the rejected ore being elevated to a swivel spout which discharges it into any one of the bins on the second floor, where it can be held, if necessary, pending settlement; after which

it is trammed over to the general ore bins. The sample from the first sampling machine drops down to a jaw crusher, thence to a roll feeder and crushing rolls. From these rolls it falls to a second automatic sampling machine, from which one-tenth is removed as a final sample, the reject being elevated to the second elevator and to the rejected ore bins on the second floor. The final sample drops down to the set of sampling rolls, thence to the coning floor. In order to make the plant entirely automatic throughout from the time the ore is fed into the crusher until the final sample lies on the con-

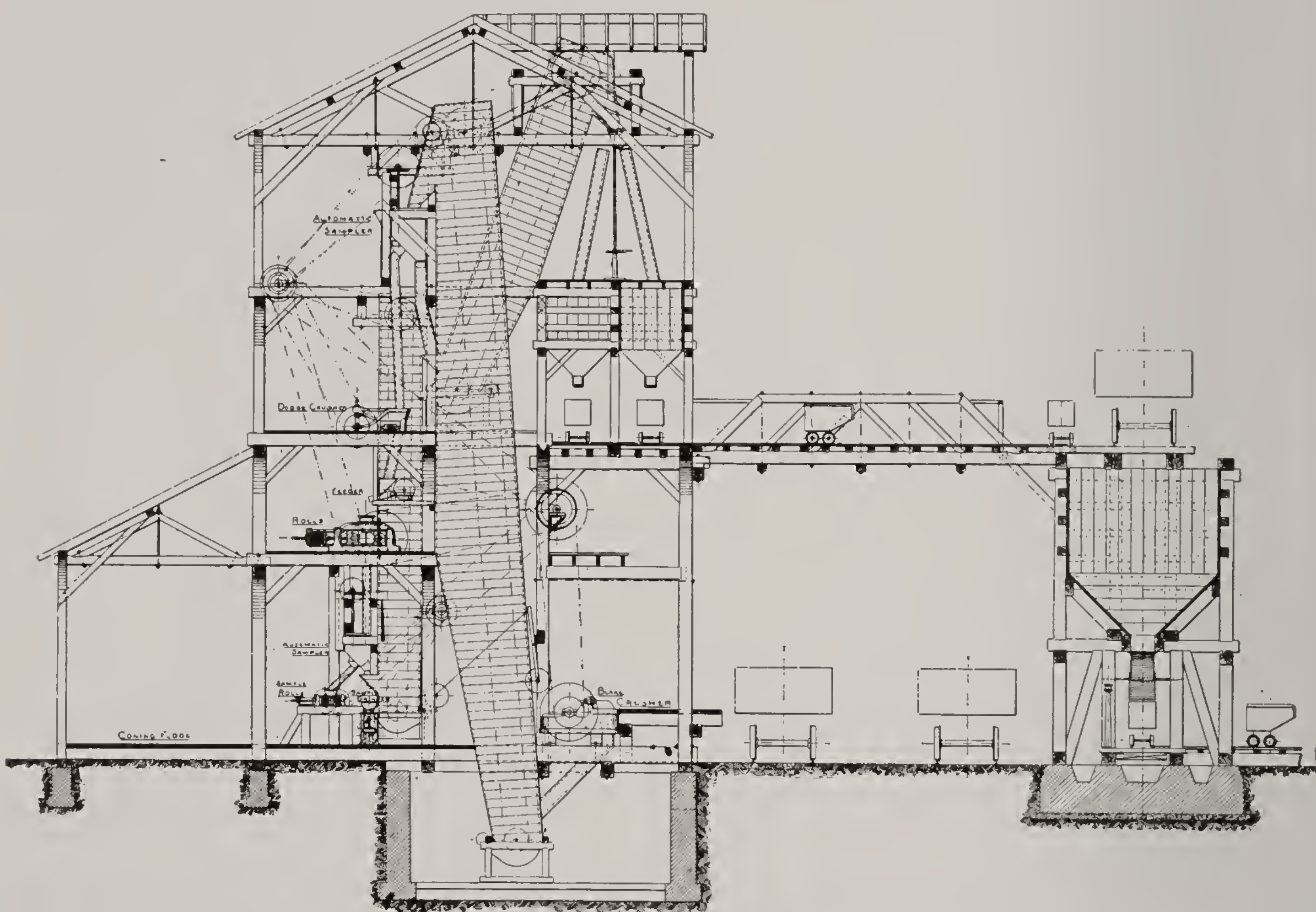


FIG. 8. AUTOMATIC SAMPLING PLANT.

ing floor, a bucket elevator is used to raise this sample from the sampling rolls to a hopper bin over the coning floor, from which it is dropped upon the coning floor as required.

The above is a typical crushing and sampling mill for custom gold ores, the main feature being the necessity of recrushing and thoroughly mixing the sample each time as it comes from a sampling machine. This method is necessary in order to obtain accurate samples of gold ores, especially so for custom work.

In sampling copper ores containing little or no gold or silver values, such elaborate sampling machinery is not necessary.

A Small Copper Smelting Plant.

The drawing reproduced below shows a very desirable layout for a plant of small size, such as we often supply to mining companies for smelting their own ores. As mentioned elsewhere in this book, the ore should be fairly high-grade to make the operation of such a plant as this profitable, not for metallurgical reasons, but because of the higher relative cost of operating on a small scale. However, this will often be more than offset by the saving of high transportation charges, if the mine is unfavorably located in this

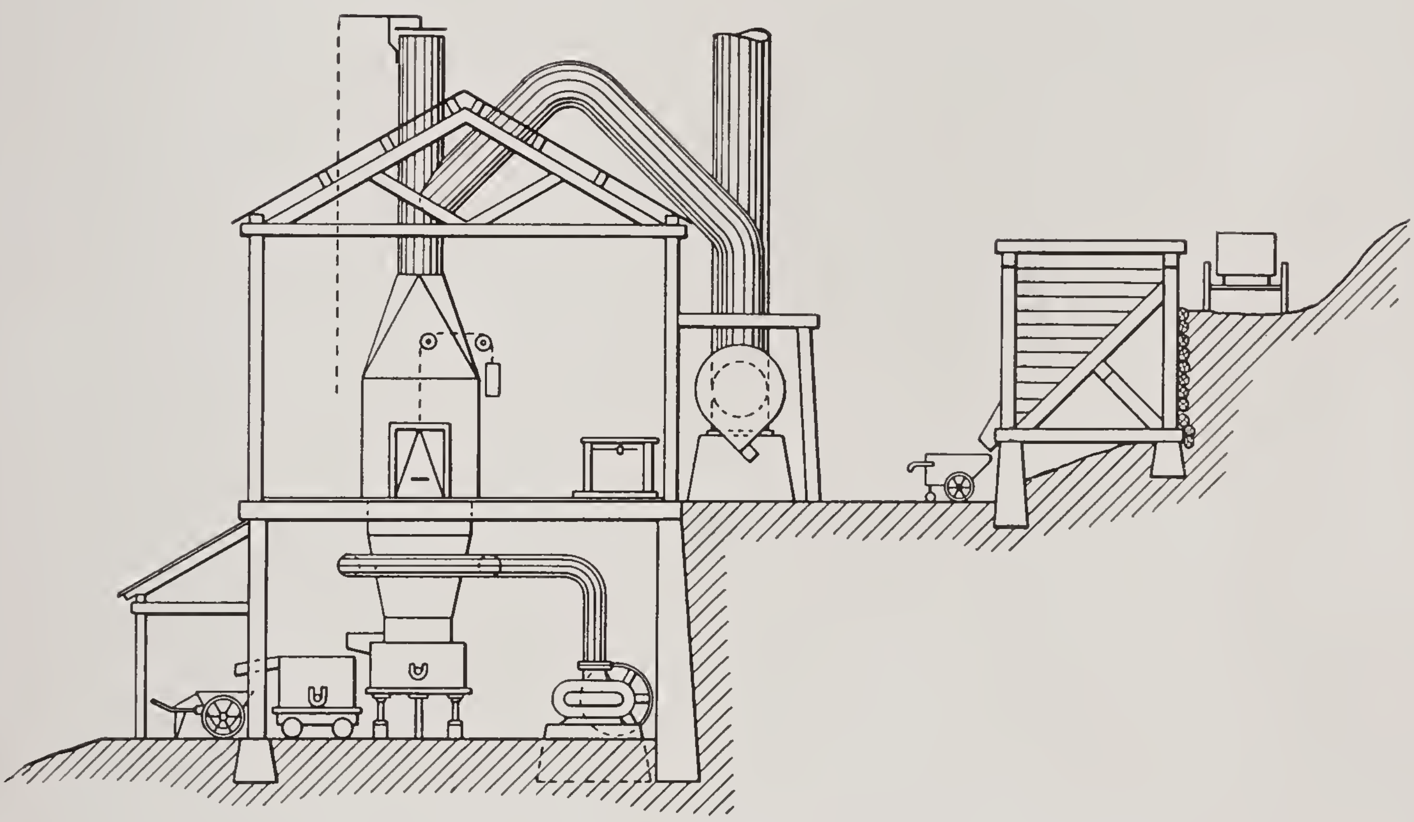


FIG. 9. SMALL SMELTING PLANT WITH ROUND FURNACE.

respect, and it is a fact that many of the larger smelters of today commenced on just such a scale.

The plant has a hill-side site, the ore being delivered from the mine by wagon, into bins placed at such height that the ore is drawn from them on the feed floor level. The charges are made up here with a minimum of labor for a plant of this size. The power plant and blower are placed on the tapping floor level and the slag is disposed of in hand pots.

The furnace downtake connects with a dust flue, which leads to a stack, and there is also a bleeder stack with damper. The dust flue is placed on the charging floor level.

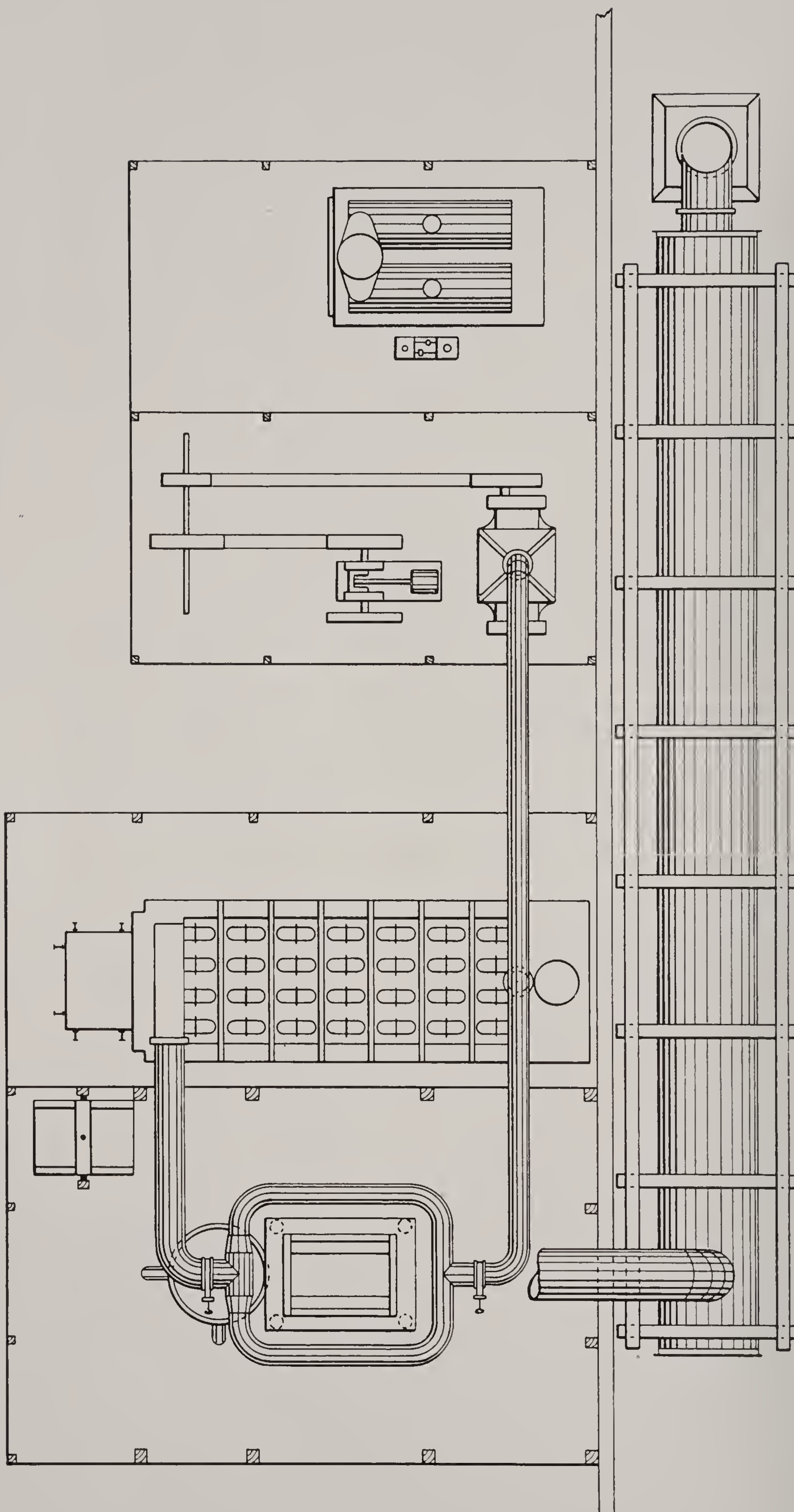


FIG. 10. HOT BLAST COPPER MATTING PLANT.

Hot Blast Copper Matting Plant.

The plant shown on this and the opposite pages is a compact and efficient one for copper matte smelting with hot blast.

The blast pipe from the blower leads to the U-pipe hot blast stove, after passing through which the blast is led to the bustle pipe of the furnace. It will be noted that the blast main from the blower is continued direct to the furnace. This is to enable the furnace to

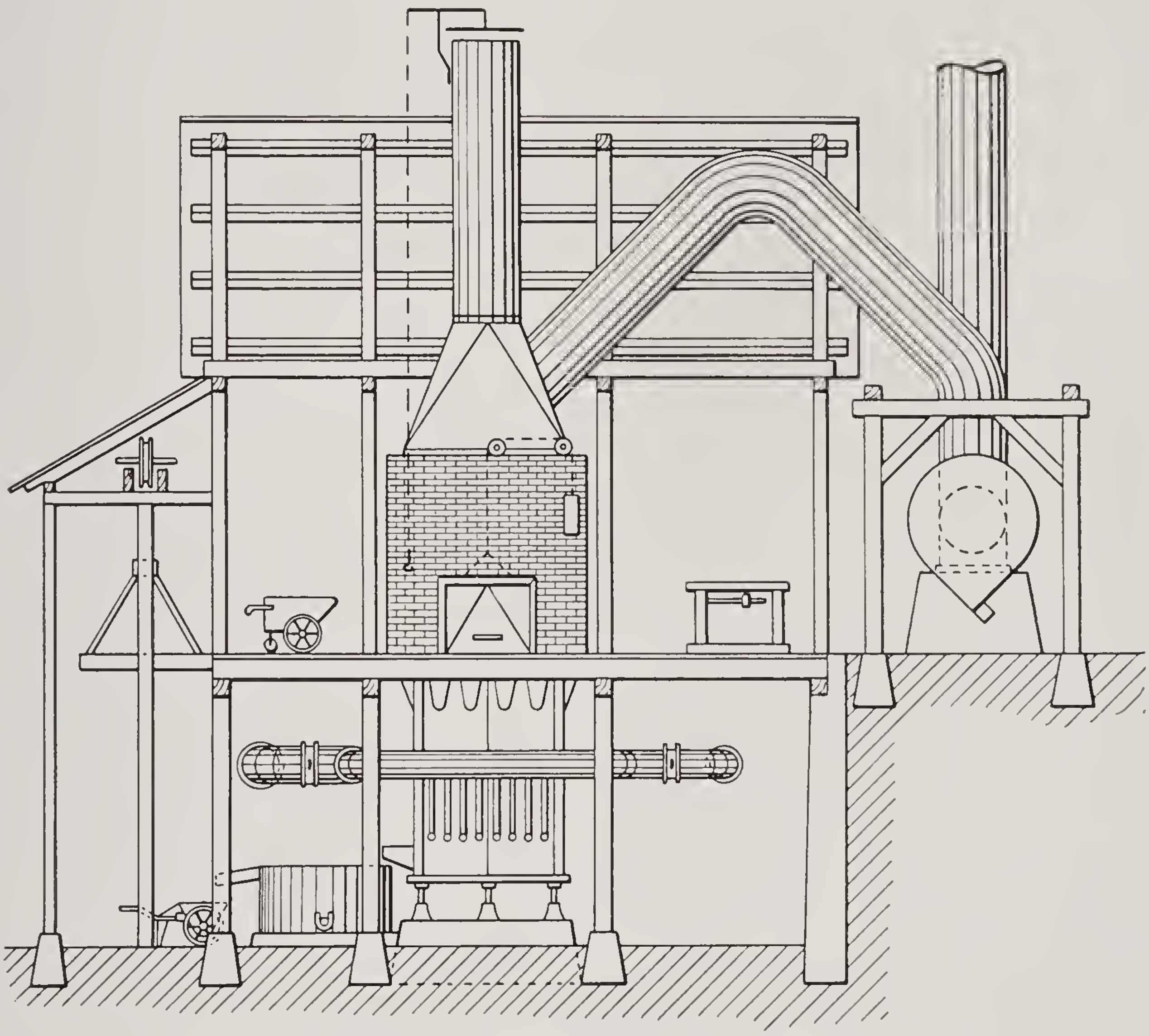


FIG. 11. HOT BLAST COPPER MATTING PLANT.

be run with cold blast, should the stove be temporarily out of service, by means of the blast gates provided for that purpose.

A round, stationary forehearth is shown in which the continuously flowing stream of slag and matte separates, and from which the slag overflows and the matte is tapped at intervals. The dust chamber is placed, as usual, on the feed floor level for economy in handling flue dust, and a platform elevator is shown, for raising foul slag, barrings and other material requiring resmelting to the feed floor level for charging into the furnace.

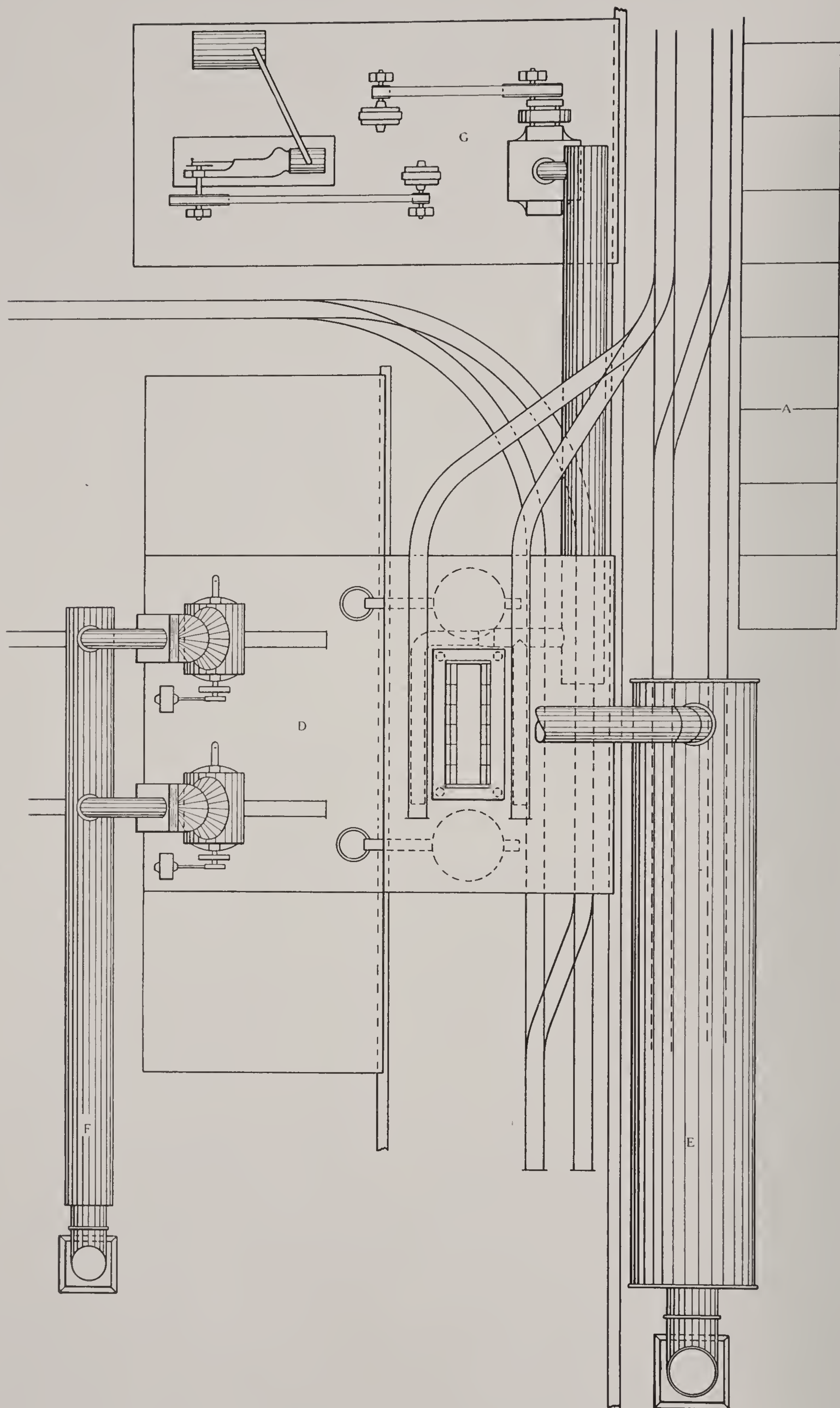


FIG. 12. COPPER MATTING AND CONVERTING PLANT.

Copper Matting and Converting Plant.

The plan and elevation here shown illustrate the general arrangement of the blast furnace and converter department of a smelting plant designed with a view to its subsequent convenient enlargement.

The ore bins are shown at *A*, the charge floor at *B*, and the tapping floor at *C*. The tracks for handling the charges and slag are shown in the plan, the tracks which serve the furnace and lead to the ore bins and dust chamber *E*, being on the level above the tracks for slag disposal. The furnace is placed on a bench above the converters,

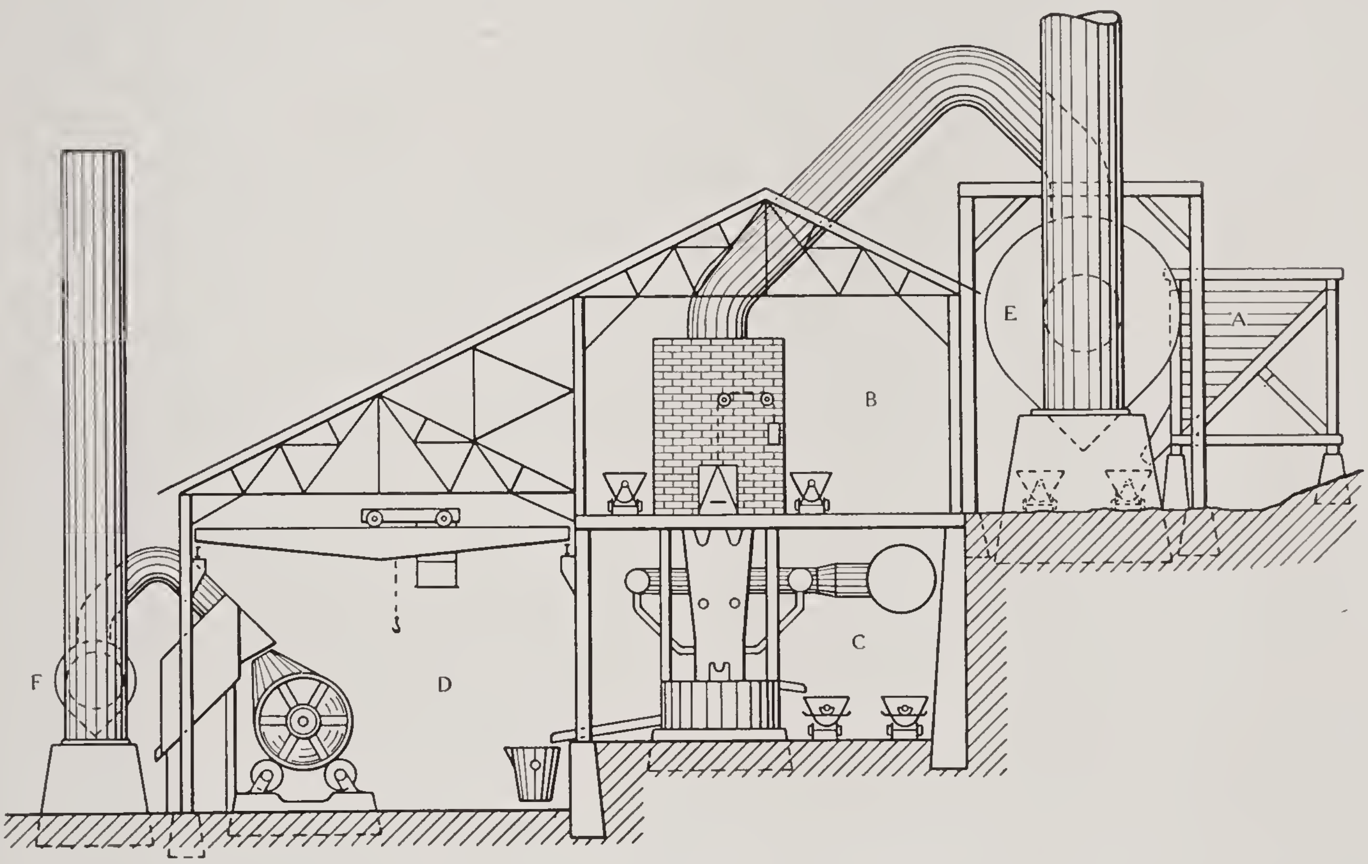


FIG. 13. COPPER MATTING AND CONVERTING PLANT.

and the matte is tapped directly from the forehearth into a ladle on the converter house floor *D*, and charged into the converters by the traveling crane. A separate dust chamber for the converters is shown at *F*, and the power plant at *G*.

In each end of the converter house is a bay, one for relining and one for storage of converter shells. Increase in capacity will be secured by extending the furnace and converter buildings longitudinally and with this end in view the blast main and dust flue are of extra size. The power plant can be added to in the opposite direction.

Hot Blast Smelting.

If the amount of air blown into a blast furnace were closely watched and regulated to suit varying conditions in the same manner as the coke and constituents of the charge are varied from time to time, much better results would in general be accomplished. The blast, however, is ordinarily given no attention except in time of emergency, the blowers being usually run at constant speed and the solid components of the reaction mixture varied to secure the desired results at constant blast volume. This is not only neglecting a factor susceptible of adjustment but is evidence of a failure to adequately appreciate that the air, although intangible and obtained without cost, is just as real an ingredient as any of the others which react together to bring about the smelting of the ores.

Every pound of air which is blown into a blast furnace has to be heated to the smelting temperature before it escapes. The only constituent of the air necessary for the reactions is the oxygen, and as the oxygen is only about 23 per cent. of the air by weight, every pound of it blown into the furnace is accompanied by over three pounds of nitrogen, and this inert gas has also to be heated to the smelting temperature.

The magnitude of the heat losses due to heating the nitrogen is not readily appreciated without recourse to figures. In an ordinary blast furnace running with cold blast, from a ton and a half to two tons of air is blown for every ton of charge smelted, the specific heat of air being about .25 while that of the average ores and fluxes is about .20. Thus the quantity of heat required to bring the air up to the smelting temperature is twice, or more than twice, the amount necessary to smelt the charge. This means that of the total heat produced, but one-third is utilized in smelting the charge, while two-thirds is consumed in heating the air. Here, then, is a heat loss incomparably greater than any other, but one which can be very greatly reduced. It can be done by preheating the blast.

To the application of hot blast is due the great economy and efficiency realized in modern iron smelting practice, for it is the application of heated air blast that has made the great iron furnaces of today possible. Blown with cold blast not one of them could run a week. Heated blast, making uniform conditions of combustion and of consequent reactions possible in each individual cross section of

the furnace, has made high blast pressure possible, without which furnaces of large cross sectional area could not be blown. There is no condition of blast temperature applying in iron smelting that does not apply with equal force and effect in lead smelting for gold and silver and in copper matting. Localization or distribution of heat, according to conditions demanded by the reactions sought to be realized, are accomplished by formulating suitable relative proportions of air temperature, pressure and volume, cross section of the furnace at the tuyeres and general dimensions, with a certainty and regularity not possible in cold-blast smelting.

The air blast in iron smelting is heated by the inflammable gases, chiefly carbon monoxide, which are evolved. Little or no such gases escape from furnaces smelting the ores of copper, lead, silver and gold, and hence to heat the air blast for these, other means must be resorted to.

If in any particular zone of the furnace a given condition of temperature, oxidation of fuel, and incandescence is necessary, then that condition is desirable in the whole of that zone. Intense heat is a necessary condition of the smelting zone of a furnace. Cold, purely as cold in the air blast introduced for the purpose of producing any useful modifying effect on a zone of the furnace where incandescence is a normal and necessary condition, is an absurdity. The effect of such cold can only have a retarding and disturbing influence in that zone.

If the current of cold air could be kept constantly impinging on the glowing coke, then to overcome its cooling influence would be only a question of fuel added; but it is not so, because such incandescent fuel as a sharp blast of cold air is caused to impinge against, is at once cooled—blown out, as it were—and it is only after the blast of cold air has passed through the heated mass of material, and becomes heated thereby, that it can strike directly upon incandescent fuel without deadening or cooling it. This is plainly seen in the operation of any cold-blast furnace, for, on looking into the tuyeres, they are generally seen to be black and to look cold throughout, except that far in, an occasional bright spot may be seen. Such bright spots are always protected from the impact of the cold blast by the cooled, or partially cooled, material at the tuyeres, against which the air impinges on its entrance to the furnace, and thence finds its way around through the heated

mass of furnace material and becomes itself heated. It is then prepared to perform its functions in the necessary reactions. The cooling in spots and patches caused by forcing a blast of cold air into it, curtails the area and the efficiency of the smelting zone, not only in propertion to those abnormally cooled spots or patches, but far more than this, for they lie there in the way of the blast, obstructing and preventing it from circulating freely throughout the incandescent zone, which it necessarily should do, for the requisite supply of oxygen to each and every individual inch in that section. Not only is the room that such cooled areas occupy lost absolutely and to be deducted from value of cross section, but their adverse effect on the furnace operation, by deflecting the blast upward or downward, anywhere away from where it is needed to where it is not needed, is still more serious, for no possible good, but much harm, must come as a result of blast blown against cooled masses of furnace material, and deflected thence into material from which heat is abstracted by the cool areas. It is only the air that gets around these cool spots in some way and into the burning fuel, and is then heated, that does effective duty.

In like manner and for like reasons combustion may be checked and the smelting operation ended by a very violent blast of cold air in a furnace burning carbonaceous fuel, and it is for this reason that very large furnaces can not be operated with cold blast. Whenever the furnace is so large that the blast pressure must be increased to several pounds, in order to penetrate to the center of the whole mass of furnace material at the tuyere zone to maintain combustion there, then the excess of cold extinguishes the fire—blows it out, as it were—in continually widening areas in the neighborhood of the tuyeres, where it is introduced, and for distances inward greater and greater as blast pressure is increased, but only in patches or spots until the center is reached and cooled so much as to stop the smelting operation all along the center line. The half melted mass of unsmelted material cools more and more, growing larger and larger, until it is finally connected here and there with the cold patches between the center and the sides, and now excessive irregularities are culminating in a frozen-up furnace, often solid at the center, while yet partially open along the sides.

A part of the air sent to a blast furnace is for the purpose of generating heat by the burning of fuel to raise the temperature of

material within the furnace to a point at which it is possible for the desired chemical reactions to take place rapidly, and further to melt such material when it reaches the tuyere zone; while another part is required for its oxidizing effect higher up in the furnace on ores carrying sulphur, iron, etc. There are large proportional areas, especially in the neighborhood of the tuyeres, in every cold-blast furnace, in which the desired reactions can not take place because the blast of cold air keeps these areas too cool to admit of them. Witness the cold, dark spots or patches, and often the whole mass of material, in the neighborhood of the tuyeres in every cold-blast furnace. Proportionally as the air is sent hot into the furnace these cool areas are reduced in size and in far greater proportion is the capacity and efficiency of the furnace increased. Zinc crusts and other accretions of kindred nature obtrude less difficulties to combat when not complicated by the presence of cold inactive spots produced by the cold of the air blast.

A pound of carbon requires 11.6 pounds of air for its consumption, and conversely for each pound of carbon that is saved from burning in the furnace by burning it in contact with the blast before it reaches the furnace, the cooling influence of 11.6 pounds of cold air is kept out of the zone of intensest heat.

In cold-blast furnaces there is a constant tendency to burn too high up above the tuyere zone, which is caused by the cold air cooling, relatively, all material at the tuyeres, while itself being heated up to the temperature at which it is possible for it to become a factor in the reactions to which it is necessary.

And so it turns out that in the absence of a heating stove outside the blast furnace in which the air blast may be heated, the furnace itself at its most vital and most sensitive part, the tuyere zone, must be utilized as a stove for that purpose primarily and at the expense of its efficiency for its other duties and functions.

Hot air is a most potent factor in facility of control in furnace working. Eliminating the element of cold from the air blast removes the one unmanageable factor in blast furnace smelting. It is unmanageable because the course or direction of the air when it enters the furnace is largely determined by the dark areas and patches of cold material, rendered so dark and cold by the cold of the air blast impinging against it.

An air blast heated to 800 degrees Fahrenheit, on the contrary, does not cause serious local cooling when blown into the tuyere zone, but causes the coke to glow brighter and burn hotter. Less coke is needed there and hence less air to burn it, or, conversely, if as much air be blown hot as would be blown cold were the furnace run on cold blast, then the smelting capacity will be greatly increased.

Because the blast is heated it does not follow that the furnace need be, or would be run hotter than is common or desirable. Hot blast does not necessarily involve increased temperature in any one zone of the furnace. Incandescence at the tuyere zone where the air blast enters, is a necessary condition of every blast furnace, but the temperature of the heated blast being always below that of incandescence, the heat of that zone and of the whole furnace is within easy and accurate control.

Assume a furnace 42 by 168 inches cross section at the tuyeres, into which 10,000 cubic feet of cold air is blown per minute, and three hundred tons per 24-hour day of sulphide and other ores, fluxes and fuel are charged in, the percentage of good coke being 11 per cent. of the charge.

The 10,000 cubic feet of air blown in each minute weigh 761 pounds at sea level, with normal temperature 62 degrees Fahrenheit. Three hundred tons of charge per day of 24 hours is 417 pounds per minute; the coke, being 11 per cent. of this, is 45.87 pounds, say 46 pounds per minute. To burn pure carbon two and two-thirds times its weight in oxygen is required. Assume 10 per cent. off, for ash and other waste, and there is left 41.4 pounds of carbon, which, multiplied by two and two-thirds, gives 110.4 pounds of oxygen, or 480 pounds of air, the extreme minimum possible. This, from 761 pounds of air blown in, leaves 281 pounds of air per minute absorbed in burning sulphur and iron, in other reactions, and some passing through the furnace unchanged. An ore charge that has enough sulphur in it to run cold blast on 11 per cent. fuel charge will always run on 3 per cent. and less, with 800 degrees Fahrenheit hot blast.

By calculation as before, but now applied to hot blast, 3 per cent. of the charge being fuel would absorb 131 pounds of air, which, added to 281 pounds blown in the cold blast and not accounted for as combined with carbon, assumed again as excess in the case of hot blast, makes a total of air required to drive the hot-blast furnace 412 pounds, or 5,400 cubic feet of air required in the hot-blast

furnace for a given duty, as against 10,000 cubic feet in the cold-blast furnace. It is only this smaller quantity, to-wit, 5,400 cubic feet of air, that must be heated in the stove for such given duty, and that, with a cheaper fuel, as against ten thousand cubic feet to be heated at the tuyere zone of the cold-blast furnace with expensive coke.

While it is true that a less ultimate number of heat units will heat a cubic foot of air to a given temperature where the air is exposed to the glowing fuel, as in the tuyere zone of a blast furnace, than it will do through the medium of heated pipes, as in our U-pipe stove, it is also true that any kind of commercial fuel, as coal, wood, oil or gas, is suitable for heating the U-pipes of a stove, while in the blast furnace only the most expensive fuel, as coke or charcoal, can be used, and the heating of the air is there done with this expensive fuel.

In a general way, with the average conditions as they obtain throughout the country, with lower-priced fuel adapted for heating air in the U-pipe stove, as compared with the high-priced coke that must be used in the blast furnace, air may be heated as cheaply, pound for pound, to a temperature of 700 or 800 degrees Fahrenheit in a well designed stove as in the smelting zone of the blast furnace.

In the cold blast furnace the cold air is blown in at the tuyere zone, and a part of it is there absorbed in keeping up the coke fire, while the excess over that so used is heated at that point, and passes thus hot into the zones of the furnace above, and there contributes the necessary oxygen to burn the sulphur. For this reason most of the sulphur is burned high up in the cold-blast furnace instead of being burned at the smelting zone, where its calorific effect can be of any value in the smelting operation.

When sulphur is burned in the higher zones of the furnace, its tendency is to carry the smelting zone bodily high up, and when this occurs the furnace soon freezes up. Burning much sulphur above, as must always be done in a cold-blast furnace, contributes to, and usually produces, hot top; and hence cold-blast furnaces running on a high sulphur charge nearly, or quite always run with hot top.

A cold blast matting furnace, with a considerable sulphur content in the charge, and running with a hot top, will run hot blast on the same charge with a cool top; the calorific value of the sulphur

in the charge will be utilized and that equivalent of heat directly saved in coke.

In smelting oxides to black copper with cold blast, where the base is chiefly iron, the fuel required is about 16 per cent. of the charge, the percentage of fuel increasing where iron is replaced by lime.

In smelting sulphides containing 15 to 25 per cent. sulphur in the charge, with cold air blast, about 10 per cent. to 11 per cent. of the charge must be carbonaceous fuel. Thus some of the sulphur is burned, saving some coke, the air necessary to burn this sulphur being in excess of that necessary to burn the coke and being heated in its passage through.

The percentage of sulphur that a charge may carry when smelting with cold blast is limited, by reason of the tenor of the resultant matte running lower and lower as percentage of sulphur is increased. When much carbon is being burned in the furnace, thus producing much heat, much sulphur can not be burned, and therefore, if a heavy charge of sulphides, they are mostly melted down, thus lowering the tenor of the matte. It is for this reason that a high grade matte can not be produced in a cold blast furnace with a high sulphur charge. With the air blast heated to 800 or 900 degrees, the heaviest sulphides are smelted raw, with 2 or 3 per cent., or less, of coke, producing a considerably higher grade matte than is possible with the same ore charge in a cold-blast furnace.

Copper matting is essentially an oxidizing process as to the ores being treated, and every pound of carbonaceous fuel that it is necessary to use in the process for the purpose of producing heat whereby the necessary reactions may take place, is a direct obstacle to the realization of the best results in tenor of matte, because in burning such fuel much carbon monoxide is produced, which burns at once in the presence of the necessary heat, robbing FeO or SO_2 or air, or all of them, of oxygen, sending the iron of the first to the matte to encumber that, instead of allowing it to combine with silica to form slag, forming sulphur from the second and sending the sulphur to the matte again to encumber that, reducing its tenor, instead of allowing the sulphur to go off as sulphurous acid gas, and the third, the air, robbing that of oxygen that is needed to combine with the iron and the sulphur of the ore to dispose of them, the one for the

slag as a necessary constituent, the other to the chimney and out of the way.

There are none of the reactions involved in copper matting of pyritous ores in which carbon is necessary or a desirable factor. Its sole office in that class of smelting is the production of heat necessary to the operation. It follows that the less of carbonaceous fuel that can be burned in the furnace for the production of heat necessary, and the more the sulphur of the ore that can be utilized for heat production, the higher grade the matte product will be, other conditions being parallel. The utilization of sulphur as fuel involves furnace conditions not vitally necessary to smelting with carbonaceous fuel, in that the calorific value in heat units in the former is much lower than in the latter.

The foregoing should make plain how the amount of blast and the quantity of coke are interdependent and how heating the blast reduces the coke and reducing the coke again reduces the blast. The net result in practice is a gain of about 50 per cent. in tonnage smelted, better concentration and greater regularity in operation.

The Vaporization of Jacket Water.

(Patented.)

In many localities the matter of jacket water supply is a very serious one, either from absolute scarcity, expense of pumping, or cost, where it has to be purchased. This led us to a serious study of the problem, and our solution of it, the Nesmith patent system of vaporization, not only reduces the amount required to one-eighth of that ordinarily necessary, but also provides what experience has proved to be the best method of cooling even where water is abundant.

Some smelter operators run so much water through their jackets that it is discharged at a temperature much below the boiling point. Their reason for this is primarily to obviate the close attention otherwise necessary and they also think that they are on the safe side and that the cooler the jackets are run, the better. This is a mistaken idea. Aside from the fact that an important loss of heat, which must be compensated for by additional fuel, results from such practice, the life of the jackets is much greater when they are run with the discharge as near the boiling point as possible. Both cast

iron and steel have greater tensile strength and a higher elastic limit at 400 degrees Fahrenheit than at lower temperatures, and the hotter jackets can be kept, the more durable they will be. More cast iron jackets are broken and steel jackets damaged by running an excess of cold water through them than in any other way. The sudden admission of cold water to a cast iron jacket which has been running hot is especially liable to cause its failure.

As indicated by its title, the principle upon which this system is based is the taking advantage of the latent heat of vaporization of water. The magnitude of the saving thus effected is plainly apparent in the following figures in which the British thermal unit is used, as the Fahrenheit scale of temperature is still the most familiar and most commonly used in this country except in high temperature work.

The heat absorbed by one pound of water at 212 degrees F., in passing into steam is 966 units, the application of this amount of heat being necessary to produce the change of state. In cooling jackets in the ordinary manner, the heat units carried off by the water equal the number of degrees difference in temperature between the feed and discharge, and assuming the feed water temperature to be 62 degrees and the discharge 212 degrees, the maximum possible heat abstraction of one pound of water is 150 units.

If, now, the pound of water be completely vaporized, there will be 966 units added to the 150 units, or a total of 1,116 units of heat utilized. This shows the amount of water necessary when vaporized to be, $150 \div 1116 = 0.1344$ or 13.44 per cent. of that necessary where the water is discharged at the boiling point. The results in actual practice are better than this, for the discharge of the water at the boiling point has been assumed, and this is a condition which is never even closely approached, owing to the danger of supplying insufficient water.

The water obviously can not be boiled in the jackets, but our system provides means whereby full advantage is taken of the latent heat of vaporization without danger of overheating any jacket—in fact, with absolute assurance of all jackets being continuously and evenly cooled.

The vaporizing system operates in a manner similar to the hot water system ordinarily installed in residences, in which the water

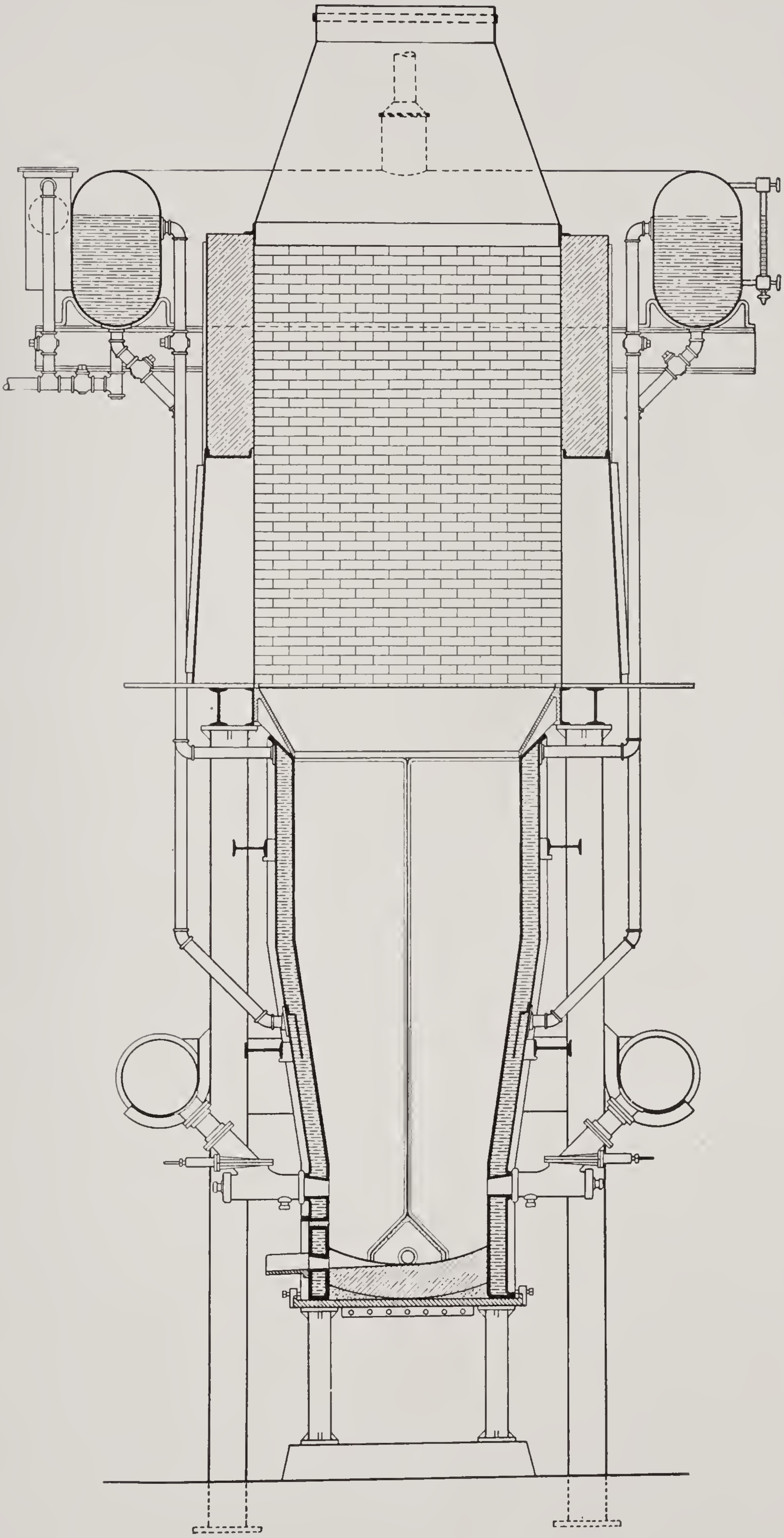


FIG. 14. NESMITH PATENT JACKET WATER VAPORIZER.

back in the range corresponds to the water jackets of the blast furnace. The arrangement of piping is similar and circulation of the water is maintained in the same way.

For use with this system the jackets are the same as with the ordinary overflow system except that the pipe connections are larger in order to reduce friction. The pipes lead to a closed drum surrounding the furnace, the feed pipes being connected to the bottom and the discharge pipes entering the drum slightly below the water level. The tendency of the hot water to rise and cold water to find the lowest level maintains a very effective circulation and any boiling takes place in the drum, not in the jackets, because the water in the jackets is under sufficient head to cause the boiling joint to be several degrees higher than in the drum which is only under atmospheric pressure. A gauge glass indicates the water level, an automatic float valve controls the admission of water to replace that evaporated, and a vapor escape pipe provided with an exhaust head conducts the steam formed to the atmosphere.

A smelter superintendent, after operating a furnace provided with our vaporization system for several months, wrote us recently as follows in reply to a request from us for information as to jacket water consumption:

"The furnace proper is using about 90 gallons per hour. I have not had time to figure this back to gallons per square foot of jacket area, but as the jacket area on this furnace is large, it should show a very low water consumption per square foot. * * * I think you are overlooking a bet in not pushing it, as it is without question the best water system for a blast furnace I have ever seen. All jackets are always at a uniform temperature; with a proper float valve absolutely no attention is required. In blowing-in we never think of the water, while with the old style overflow system it generally keeps one man busy to keep from burning a jacket. In places where water is scarce a more elaborate condenser on the exhaust head would save nearly all the water. Another very good feature is the fact that different furnace men have their own ideas about jacket water—one wants to run his water cool or cold and another hot with no two jackets the same, while with this system it absolutely cuts out the 'personal element' and the jackets must have a decided benefit from the constant temperature."

Jacket water consumption is usually determined in gallons per minute, to avoid large figures, but as is evident from the above quotation, gallons per hour would be a more convenient measure of comparison were the vaporizer system in universal use. However, on the customary basis, the exposed jacketed surface of the above furnace being 414 square feet, the water consumption was 0.00362 gallons per minute per square foot of jacket area. This was a copper matting furnace. Another user of the vaporizer system, operating a lead furnace, reported a water consumption of 0.0113 gallons per minute per square foot jacket area, but this vaporizer was run without an automatic float valve and loss of some water was consequently unavoidable.

Comparison of the above with published figures for Cananea, 0.616, and for Granby, 0.31 shows an actual saving far above the theoretical, and brings out strongly the magnitude of the waste of water in cooling jackets in the ordinary way. At Granby, the discharge from the upper jackets was the feed for the lower jackets, which accounts for the large economy shown over Cananea, the amount of water used at Cananea being about what is ordinarily required.

The jacket water is commonly run into settling ponds where it is cooled and reused, but there is great loss from evaporation and seepage, to say nothing of the expense of pumping. The installation of the vaporizing system will cost less than settling ponds and it entails no continual expense, as for pumping. In addition, it provides cooling means in every way superior to the ordinary overflow method.

We have always arranged the piping of our vaporization system so that the jackets could be fed in the ordinary manner when blowing-in the furnace, and do not intend to depart from this practice although the letter above quoted would indicate that we might safely do so.

Data Required for Estimates.

As smelting consists in subjecting an ore or mixture of ores containing slag-forming constituents in proper proportions, to such conditions of temperature and oxidation or reduction as will cause the formation of a proper slag, and as chemical analysis furnishes the means for ascertaining the composition of the ores and fluxes preparatory to determining the proportions in which they may be mixed to form a suitable charge, it is a simple matter for a competent metallurgist to determine the applicability of the smelting process to any particular ore if he is provided with analyses of the ore and available fluxes. Further than this, he can closely approximate the cost per ton for smelting, and from this the probable profit or loss from the operation within quite narrow limits.

In view of these facts there is no excuse for installing a smelting plant for the treatment of ores unsuitable for the smelting method. The possibility of smelting a given ore can be predicted with greater certainty than can the possibility of treating it by any other ore treatment method.

Some ores are self-fluxing, that is, contain slag-forming constituents in such proportions that they will produce a fluid slag, but such ores are uncommon. Usually the ore is deficient in one or more of the necessary elements, and fluxes containing an excess of such element or elements must be added to it. Often it is possible to secure a flux at low cost, which, while it would not pay to smelt by itself, contains enough values to about pay its way through the furnace, but when it is necessary to add large quantities of barren fluxes the disadvantage is great, as the cost of smelting a ton of ore is the cost of smelting the ton of ore and the fluxes added to it.

The most common constituents of ores which are important from a smelting standpoint are silica, iron, lime, alumina, zinc, sulphur, arsenic, manganese, and magnesia. Other elements may be present in sufficient quantity to require consideration; thus fluorine, if in combination with lime, renders the lime unavailable as a flux, and large quantities of barium are sometimes troublesome. Copper or lead is necessary, either as the valuable constituent of the smelting charge, or as a collector of precious metals. Gold and silver are of no importance whatever in determining the amenability of an ore to smelting, but if present, they are of course important in their bearing on the financial results.

Much lead, when gold and silver are present, is very objectionable in copper matte smelting, as the lead is lost and precious metal

with it. Some copper, on the contrary, is desirable in smelting ores to lead base bullion, as it permits higher sulphur than would otherwise be possible, forming a copper-iron-lead matte, which also promotes the making of clean slags.

The analysis upon which to determine the suitability of ores for smelting should show, not only copper, lead, silica, iron, lime and sulphur, but, as certain other elements may be present in undesirable quantity, the analysis should total at least 97 per cent. This total will show few constituents in clean ores but will be made up by a greater number if the ore is a complex one. The effect of flourine on the availability of lime points to the necessity of care and completeness in the analysis, and it may also be mentioned here that alumina and zinc, when present together, are more difficult to contend with than either alone.

As in most processes of ore treatment, or other enterprises for that matter, the cost becomes reduced as the scale of operations is increased. In smelting, however, there is a lower limit of capacity beyond which it is impossible to go by reason of the difficulty of maintaining small blast furnaces in continuous operation. In lead smelting this may be taken at about 20 tons per day and in copper matting at about 30 tons per day. Even at these capacities, the ore mixture should be an easily smelted one for metallurgical reasons, and a rich one for financial reasons. These small furnaces often pay well in smelting high-grade ores at isolated properties.

The size furnace necessary for any given capacity can not be stated without a knowledge of the ore to be smelted. To do justice to the purchaser, his problem must be considered in all its phases and the equipment must be designed and constructed to meet the requirements of his particular case. This being so, it is manifestly futile to attempt a tabulation of furnace capacities and positively misleading to publish figures alleged to cover the price of equipment or cost of operating, as is frequently done by irresponsible parties.

We are pleased at all times to advise regarding the practicability of smelting any particular ores and to prepare estimates covering suitable equipment. As above indicated we will require an analysis of each of the ores and fluxes, and these analyses should not be made on random samples, but on samples from a systematic sampling of the deposits, so that they will as nearly as possible be truly representative of the run of ore which will come to the furnace when in operation.

If estimates on the cost of operation are desired, we should also have full details as to cost of coke, labor, etc.

The Blast Furnace Structure.

We have not attained our enviable position as builders of the most perfect smelting equipment without having overcome all of the mechanical difficulties which have developed during the advancement which has been made in blast furnace smelting. The modern blast furnace as we build it is a very efficient apparatus and every detail has been perfected in such a manner that purchasers may rest assured that they will be free from petty annoyances arising in operation, due to insufficient attention to details.

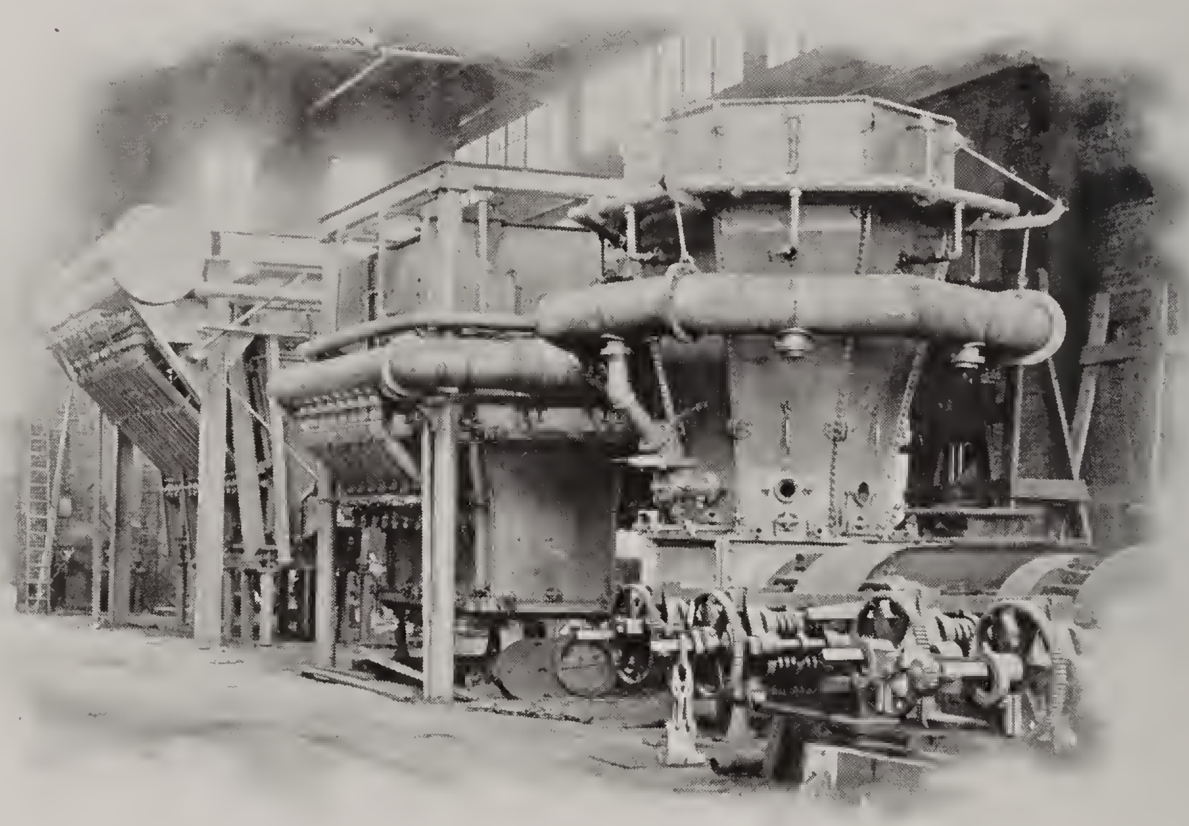


FIG. 15. COPPER FURNACES ERECTED AT COLORADO IRON WORKS.

Many of the most important advancements which have been made have originated with us and since come into general use, and while we always aim to be in the forefront as builders of smelting equipment and to produce apparatus of the most advanced type, we are always conservative in adopting innovations and intending purchasers may have the fullest confidence that they are not experimenting when buying of us.

We have no "standard" furnaces, that is, no "stock" furnaces. Each is especially designed and built for the conditions under which

it is intended to operate and can be relied upon for the best metallurgical results. Our smelting equipment is very massive, as we early discovered the necessity of putting great weight into it for the reason that ordinary calculations for strength do not apply where the material is subjected to all manner of strains by sudden temperature changes.

Every furnace which we build is completely set up in our shop and all parts are plainly marked so that there is no difficulty in erecting the furnace at destination. All the furnaces illustrated in

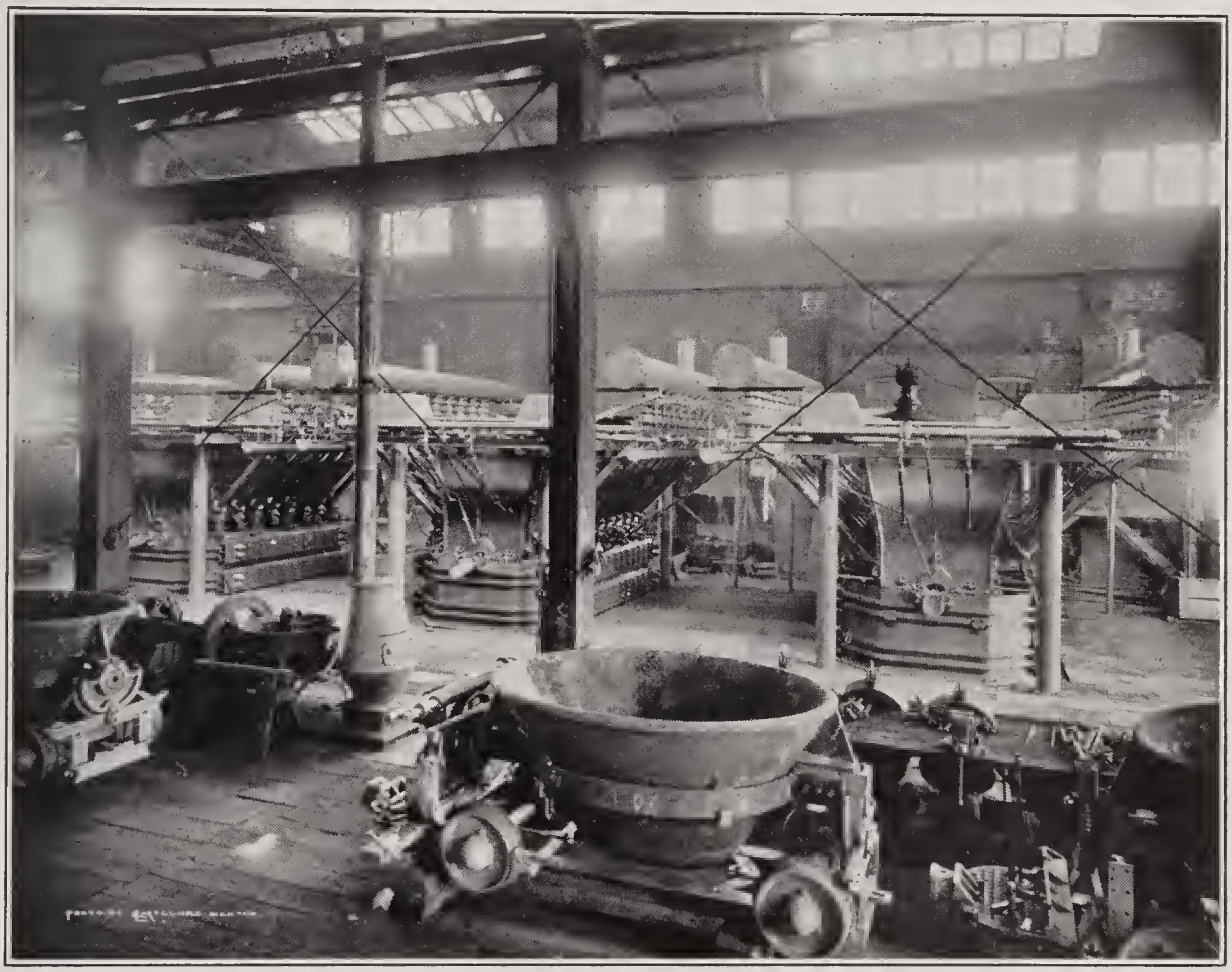


FIG. 16. LEAD FURNACES ERECTED AT COLORADO IRON WORKS.

this catalogue were built by us. We could show many more, but only include those which are necessary to bring out some special features.

It is impossible here to show all the details entering into the modern blast furnace, interesting though it might be to do so; we direct special attention, however, to a few features of special merit. In this connection it is proper to say that we are fully prepared to build furnaces to any design that may be furnished us, and that we are in no sense confined to our own ideas as to designs nor to

those in general use. It is very common for changes to be made in existing designs or entire new plans to be furnished us to build furnaces by, to conform to the ideas of customers. We are always glad to execute such orders, as we have ever been, for improvements are often thus introduced, and it is our desire always to be in the first rank in the march of improvement.

The bosh of a blast furnace has long since been demonstrated to be an important feature in its bearing on the smelting operation, and that it is essential to economical and efficient work in both lead and copper furnaces is generally acknowledged. While smelting is possible in blast furnaces having no bosh, there are few, if any, cases where a properly designed bosh would not greatly improve the results, and it may fairly be said that where smelting is carried on in such a furnace, success is attained in spite of the absence of that important feature.

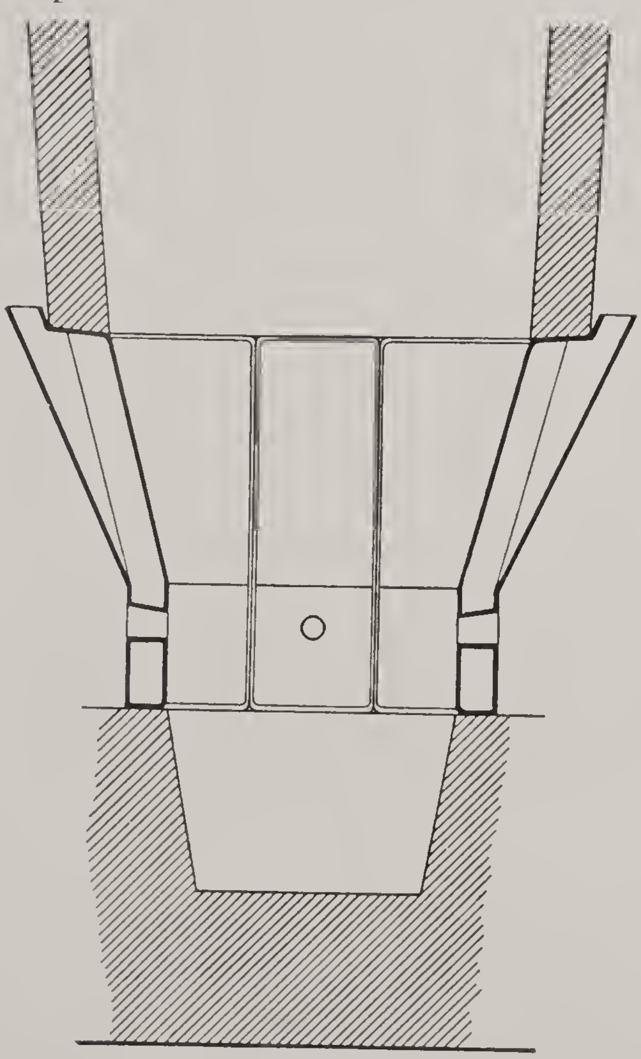


FIG. 17. LEAD FURNACE.

A furnace with straight walls is indicated for simple melting operations, such as melting down iron in a foundry cupola; but in smelting, in addition to melting, a series of chemical reactions must be brought about, the grouping or form of combination between the constituents of the charge must be changed, and bosh is important in facilitating these reactions. The reactions, so far as concerns reduction or oxidation, carbon monoxide being the principal agent of the former and oxygen of the latter, take place at a lower temperature than that necessary for slag formation, and consequently higher up in the shaft.

Time is a factor in bringing the reactions to completion, and boshing the furnace provides the means of properly proportioning the time during which the charge is subjected to the different conditions existing in the shaft from feed floor to hearth. As the upper parts of a boshed

furnace have a greater area than the tuyere zone, the charge, in passing down the shaft, moves more slowly in the upper regions than when in the vicinity of the fusion zone and a proper interior contour can thus accomplish by time of exposure, reactions which can not be accelerated.

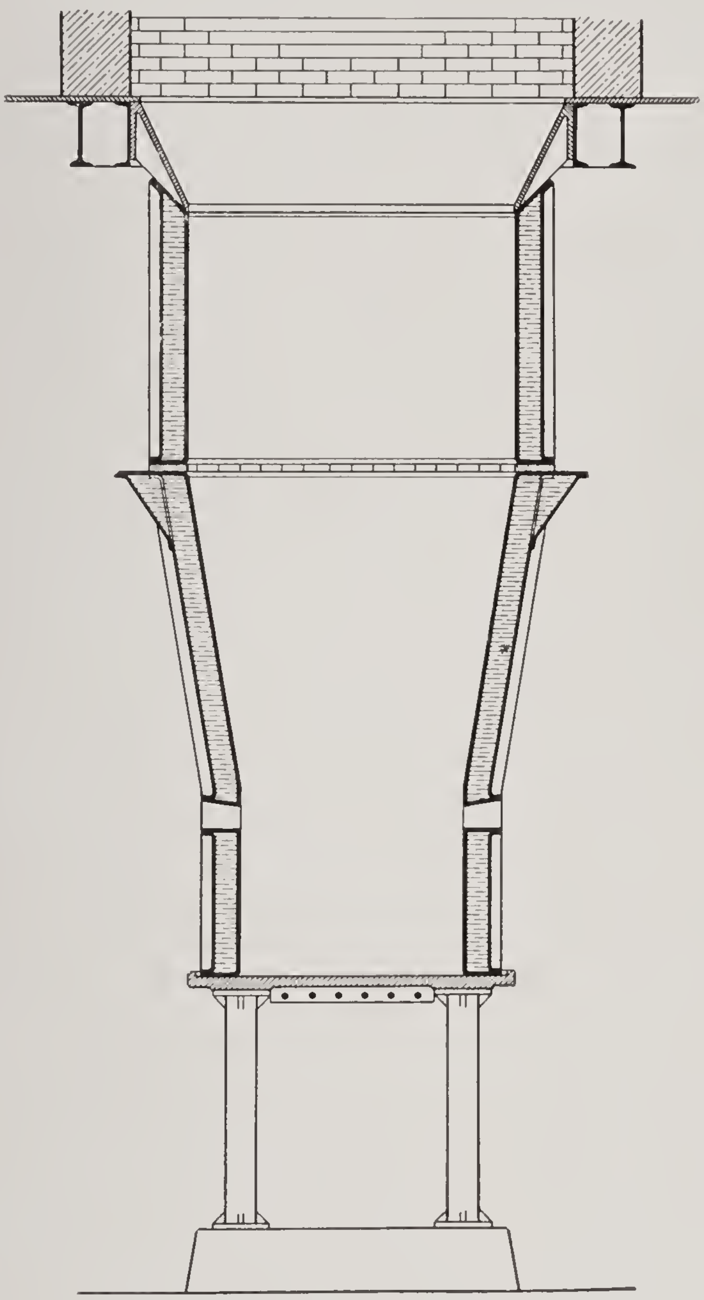


FIG. 18. COPPER FURNACE.

Bosh acts favorably as to the time element, both with respect to the ore moving down the shaft and the air passing up through it. At a temperature of about 2100 degrees Fahrenheit, the air and evolved gases have expanded to more than five times their volume at ordinary temperature, and would consequently have to pass up a straight shaft with five times the velocity of an equal weight of cold gases. As it is desirable to exhaust the gases of their contained carbon monoxide or oxygen, as the case may be, as well as their heat, before allowing them to escape, anything which will reduce their velocity will enable such use of the gases to be increased. Further advantages connected with the blast which are secured by the bosh, are the production of less flue dust and the holding of the reactions lower down in the furnace.

Straight walls within a furnace offer an easy path of escape for the rising gases, as the coarse lumps of the charge, where resting against the walls, present greater interstices than where surrounded by fine material. Bosh breaks this easy path and causes a more even permeation of the charge by the gases.

In a furnace with straight walls the whole weight of all furnace material rests on the bottom, sliding smoothly down with little friction as it melts away at the tuyeres, and the softened, half-melted mass at and near the tuyeres packs tightly, tending to ob-

struct the circulation of the air blast. In a furnace with boshed walls the boshes take the weight of that part outside of the vertical lines up from the hearth and hence cause friction on the column of ore within itself remote from the walls directly above the hearth, reducing the weight of the ore column on the hearth and at the same time causing the ore to keep turning over and working within its mass, breaking up any aggregation of sintered material that may have formed above, and strongly counteracting the tendency to pack together by reason of the fines filling all interstices, and to become impermeable to the gases on their passage upward.

In this connection we show the interior contour of two blast furnaces, one for lead ores and one for copper matte smelting. Neither of these is extreme; on the contrary, they represent standard practice, and their introduction here will show the different lines along which the development of the principle of boshing the walls has proceeded. These illustrations bring out the main points of difference between the lead furnace and the copper furnace, the former having a single tier of jackets of comparatively small height, with brick shaft above and crucible below, and the latter having jackets extending from the cast iron bottom plate to the inclined feed plates at the feed floor level. The absolute dimensions of the different parts of the shaft are varied to suit the particular work for which the furnace is designed, and in this our long experience has given us special ability.

Although all jackets are best when made of steel plate, in silver-lead furnaces the water jackets are often made of cast iron in sections about four and a half feet high, and eighteen or twenty inches wide. Of such sizes cast iron jackets can be made to stand as well and last as long as those made of steel plate; and of such sizes jacket sections can be replaced, when necessary, in half an hour, without blowing out the furnace.

The annexed illustrations, figure 19, show our improved form of curved corner cast iron end jackets and indicate the manner in which they form the round corners of the furnace in the bosh.

The jacket shown is for a small furnace, and we also show in this cut how an end tuyere opening is provided. The wider furnaces have the corner jackets made in the same manner but an end center jacket is used. The side jackets are all straight on their edges. The end jackets curve around the corners in the bosh and

come to straight lines where they meet at the sides. Corner jackets made in this form are as durable as side jackets which is not the case with square corner jackets having sharp angles in them to conform to the bosh of the sides. Those with sharp angles where they widen out, are much more likely to crack than when made with curves, as we have been making them for several years.

By this improvement a minimum number of jacket patterns is required for a furnace of any dimensions and the number of spare jackets necessary to be kept on hand is reduced.

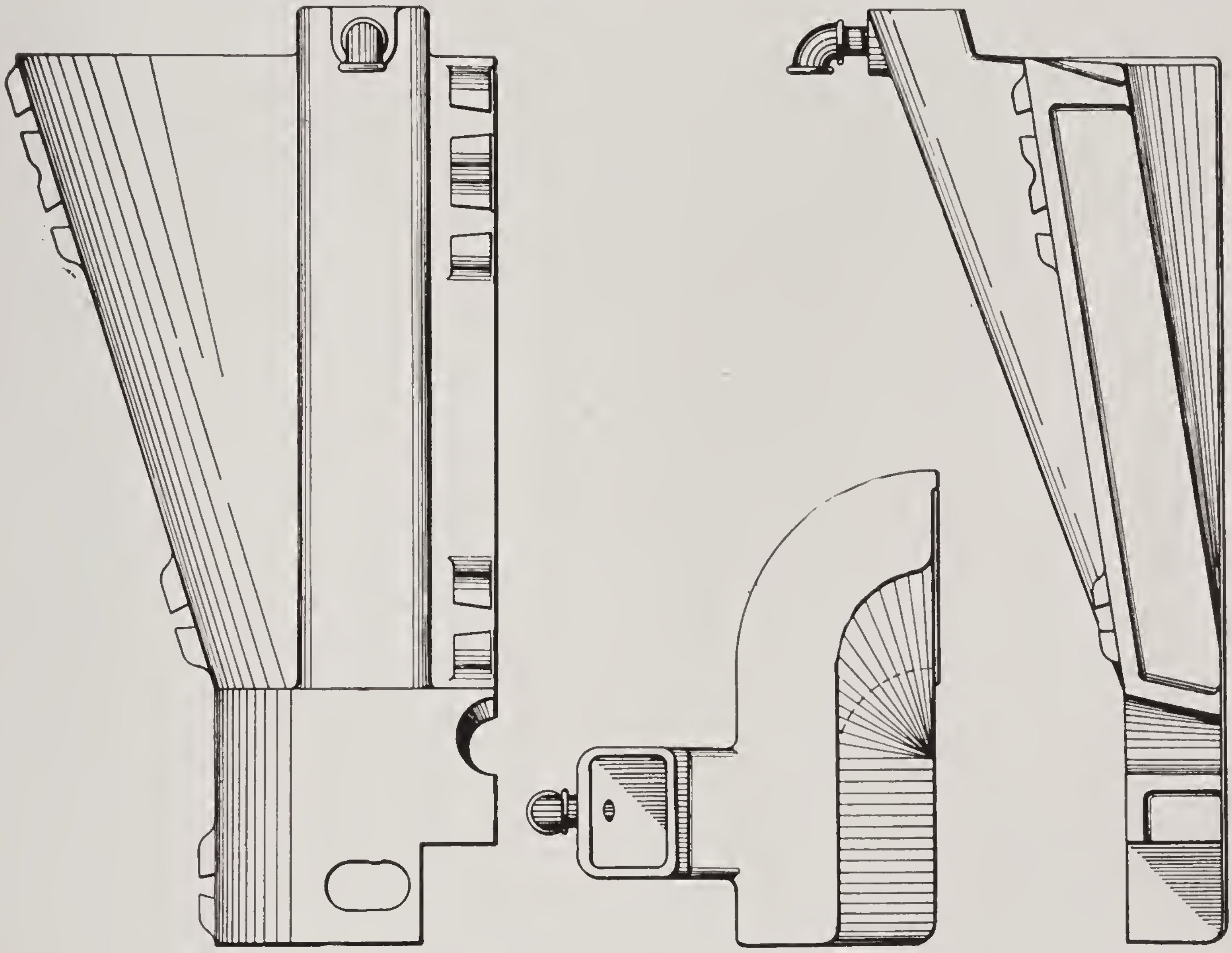


FIG. 19. IMPROVED FORM OF CAST IRON CORNER JACKETS.

An important feature of all our blast furnaces is our automatic gas escape valve. When the blower stops there is danger of combustible gas (CO) rising through the blow pipes and filling them and the bustle pipe with an explosive mixture which is liable to ignite from the furnace when the blower starts up again. Very serious explosions have resulted from this cause.

Valves have been placed in the pipes or on the backs of the jackets, but such valves are always unsafe, as they are designed to close when the blast stops and are never tight enough to perform their function properly. We devised the only automatic gas escape

valve which affords absolute immunity from gas explosions and place it on the bustle pipe of every furnace. It consists of a valve of large area which is normally open, but which closes by the pressure of the air when the blast is put on. Being at the highest point, the combustible gas, which is lighter than air, has a free means of escape into the atmosphere.

In our lead furnaces our patented steel arch bar girders now take the place of the old style mantel plates and of the later I-beam

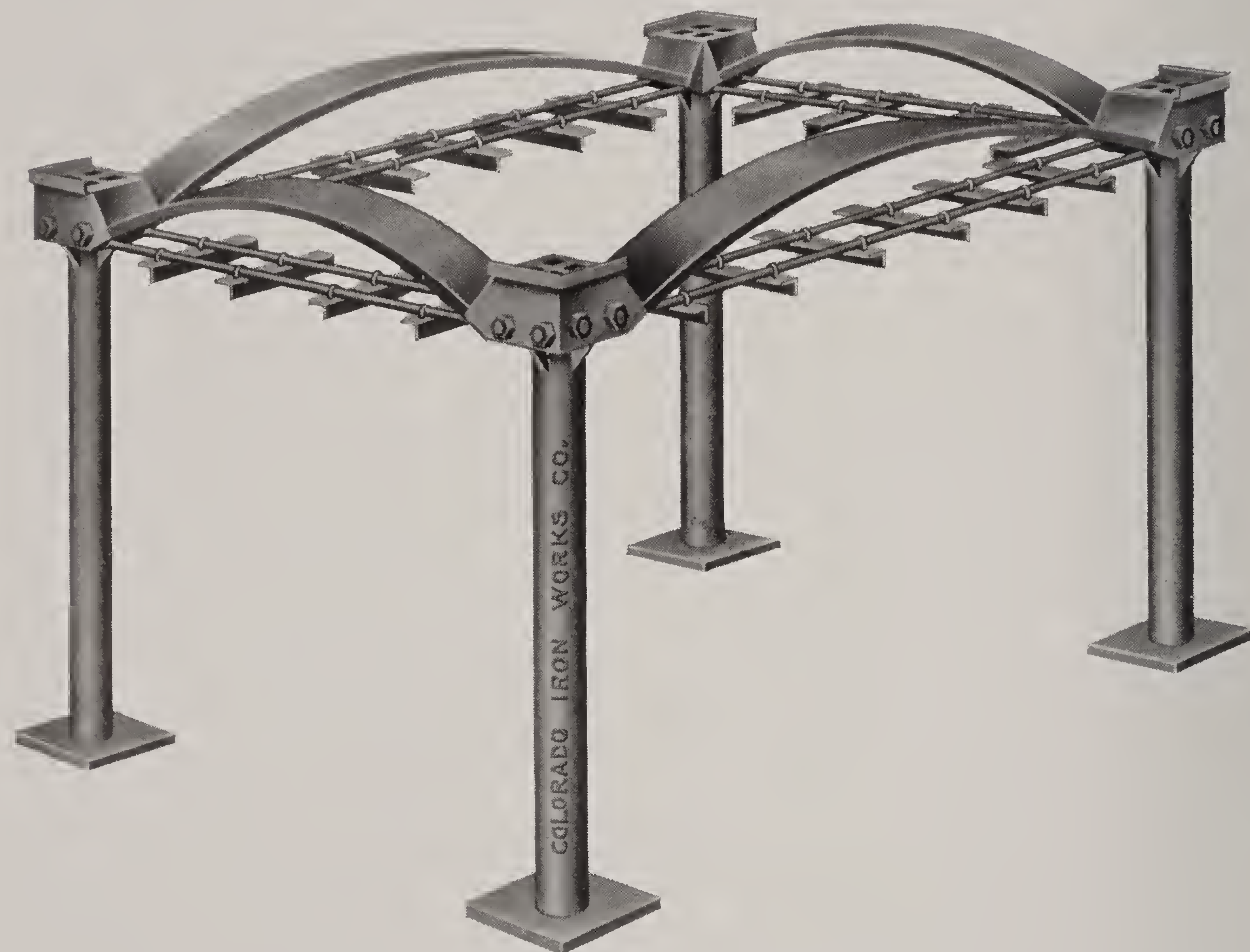


FIG. 20. PATENT STEEL ARCH BAR MANTEL SYSTEM.

mantels, both of which styles had serious objections in that it was not possible to protect them from destruction by the furnace lining burning away and exposing them to intense heat. In this system, the red brick walls are carried wholly by the arch bars, and inside them come angle bars and plates under the fire-brick lining of the furnace. When the lining burns thin, these plates on the angle bars will heat and may spring somewhat, but as they are entirely independent of the main girders that carry the walls, no damage is done to the main structure and all there is to be done is to renew the lining where it has burned out, which is usually but for a short distance above the jackets. With the old style cast iron mantel plates

carrying the main brick walls of the furnace, and which had to be wide enough to also carry the fire-brick lining, there was always the certainty that when the fire-brick lining was allowed to burn too thin, the inner edge of the wide mantel would heat and spring, cracking and shattering the main walls, and would often itself break, involving thus the not inconsiderable cost and delay of repair to walls and replacement with a new mantel. I-beam mantels are subject to the same difficulty, and being deeper vertically than the cast-

FIG. 21. PATENT WATER-JACKETED STEEL GIRDER SYSTEM.

iron mantels the trouble is aggravated. We have applied the arch bar system of mantels in most of the silver-lead smelting furnaces that we have built during several years, and not one in that time has given the slightest trouble or ever will. In some we have introduced water jacket girders, carried by the main corner columns of the furnace. These water girders take the place of the auxiliary upper jackets often required above the main jackets, and support the furnace lining instead of allowing it to rest on the main jackets as is the case where the ordinary auxiliary jackets are used, or instead of being suspended from above by a framework as is sometimes done.

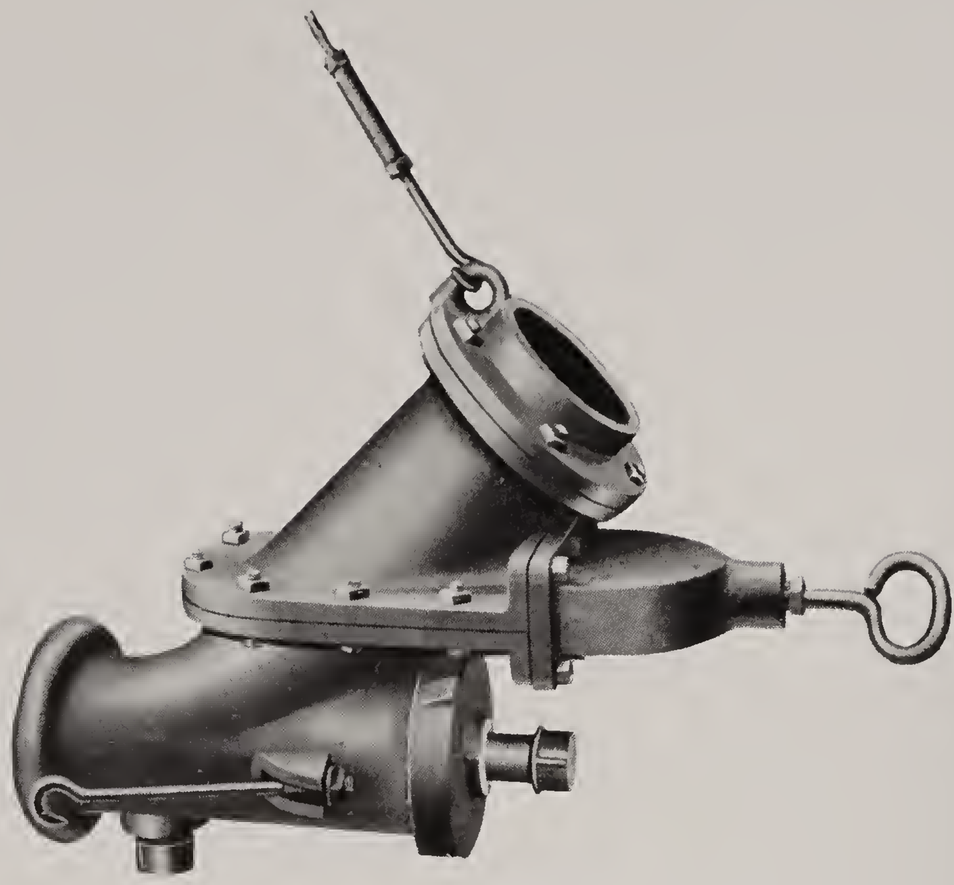


FIG. 22. IMPROVED BLAST FURNACE TUYERE.

The latest type of our improved cast iron tuyere for blast furnaces is shown in Fig. 22. An air-tight gate is built into this tuyere so that the air blast to each one can be regulated independently of the others. The peep-hole nipple is taper-fitted to the cap so that it can be instantly removed for barring into the furnace and the cap is fastened to the body by an interrupted screw so that it also may be easily removed, giving access to the entire interior of the tuyere

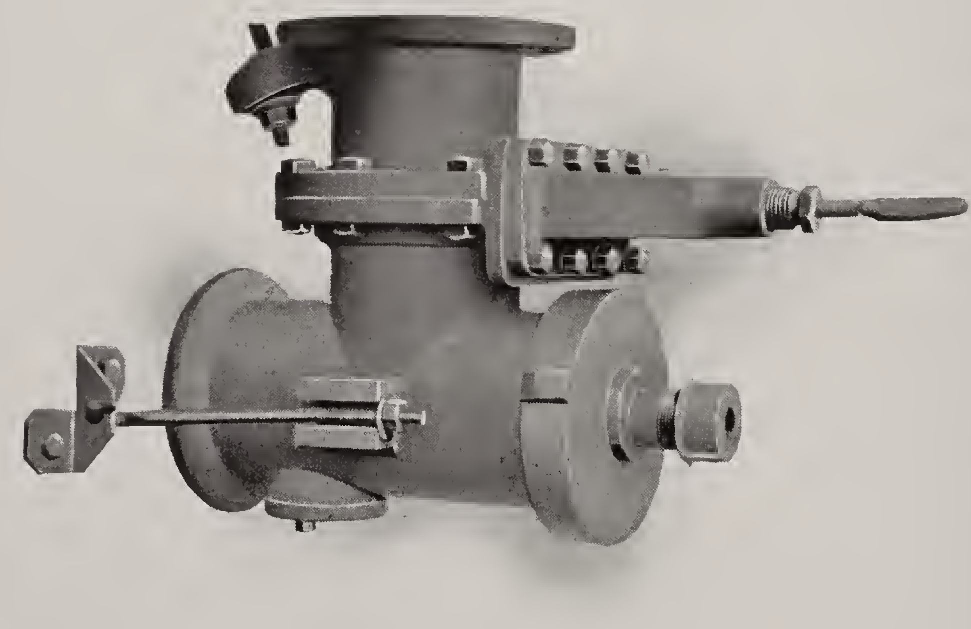


FIG. 23. BLAST FURNACE TUYERE.

when necessary. The slag escape is made very much larger than shown in the illustration and the tuyere, as a whole, has given the greatest satisfaction. It is an improvement over our earlier form of tuyere, shown in Fig. 23, and avoids the excessive friction of the air in the latter owing to the more favorable angle of the blast inlet. This type of tuyere is also used on our hot-blast copper-matting furnaces, where the blast is heated to not exceeding 1,000 degrees, Fahrenheit.

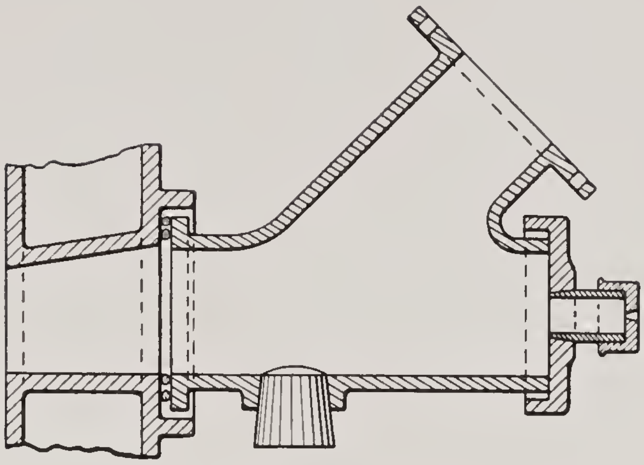


FIG. 24. BLAST FURNACE TUYERE.

In Fig. 24 we show the type of tuyere which we use on furnaces where the blow pipes are made of standard pipe and individual quick-opening valves are placed close under the bustle pipe. It is shown on a number of furnaces illustrated in this book and has all the advantages of the tuyere shown in Fig. 22, with the added one that when the tuyere is removed the valve is still in position to shut off the blast.

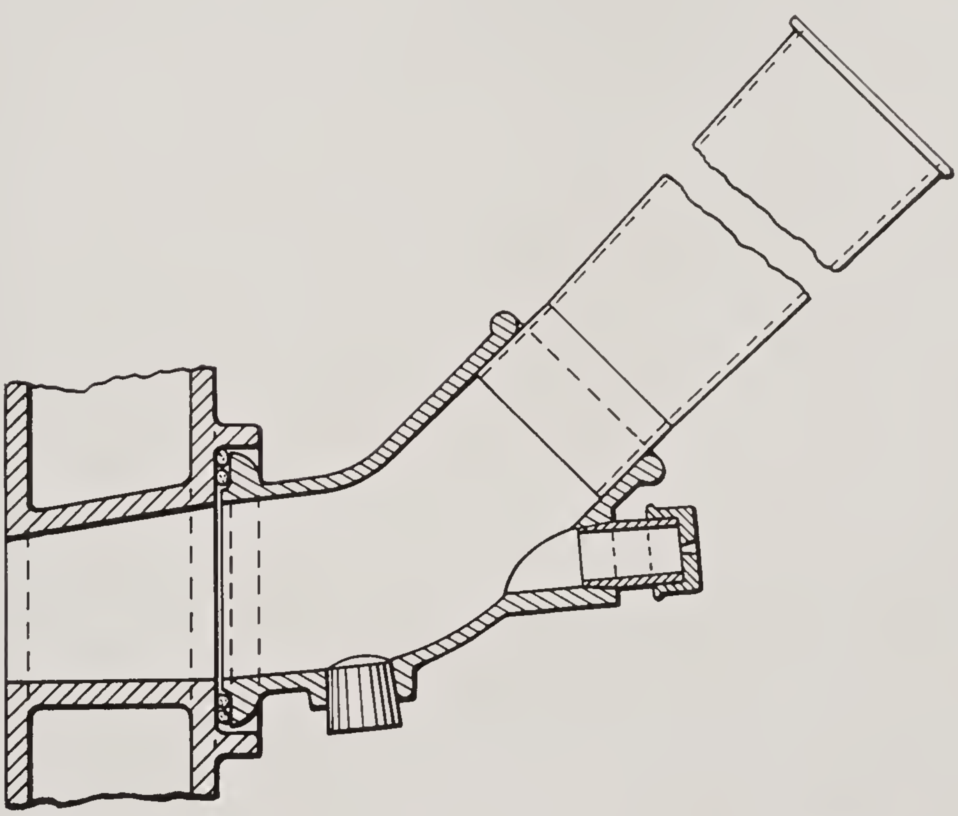


FIG. 25. TUYERE FOR LEAD BLAST FURNACES.

Fig. 25 shows our standard tuyere for lead furnaces. The jacket has a faced recess, an air-tight connection being made with asbestos packing. With this tuyere the opening in the jacket can be bushed if necessary, which is not the case with tuyeres projecting into the opening.

The combination furnace trap-spout shown in Fig. 26 is the outcome of many years' study and experience, and is the result of continued efforts to produce one that would give satisfaction.

It is constructed of ribbed cast iron plates, bolted together and lined on the inside with magnesite brick. To the outer end is fitted a water-jacketed tip made of nearly pure copper, over which the

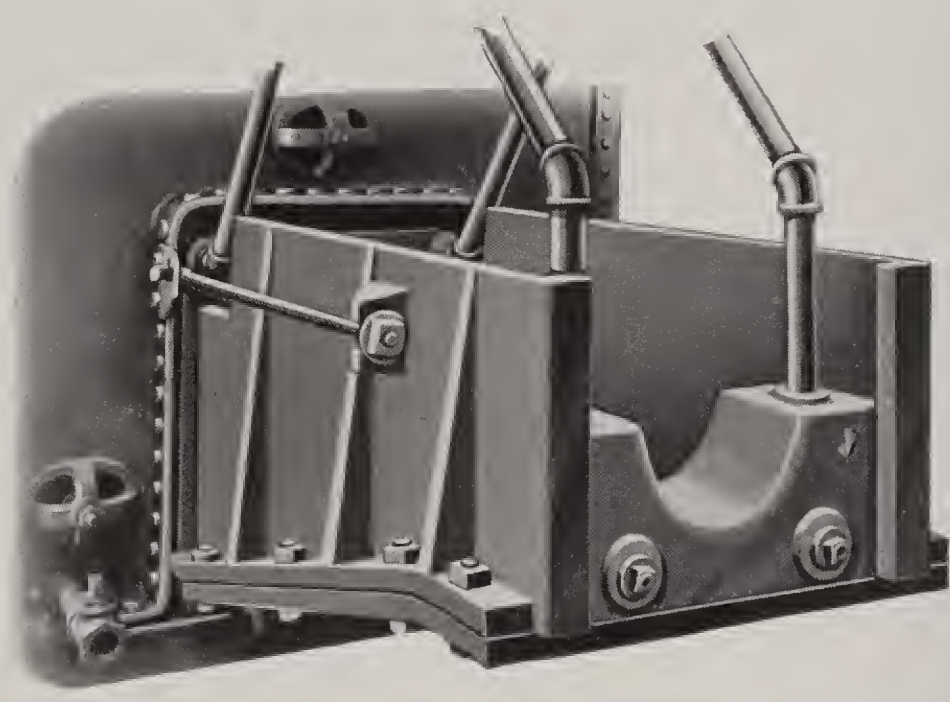


FIG. 26. GROSS PATENT TRAP SPOUT.

liquid slag and matte flow to the settler, this tip taking the most severe cutting effect of the matte. The tip has a vertical adjustment of about six inches, for the purpose of easily changing the amount of trap.

The success of this spout has been thoroughly demonstrated, and we offer it to those having difficulties with their present ones as a simple, efficient and inexpensive furnace trap-spout for copper matting blast furnacs.

Silver-Lead Blast Furnaces.

The rectangular blast furnace adapted to smelting lead ores, either alone or with dry ores, is designed along the lines of the drawing reproduced on this page. Our wide experience obtained in building the great majority of the lead blast furnaces in opera-

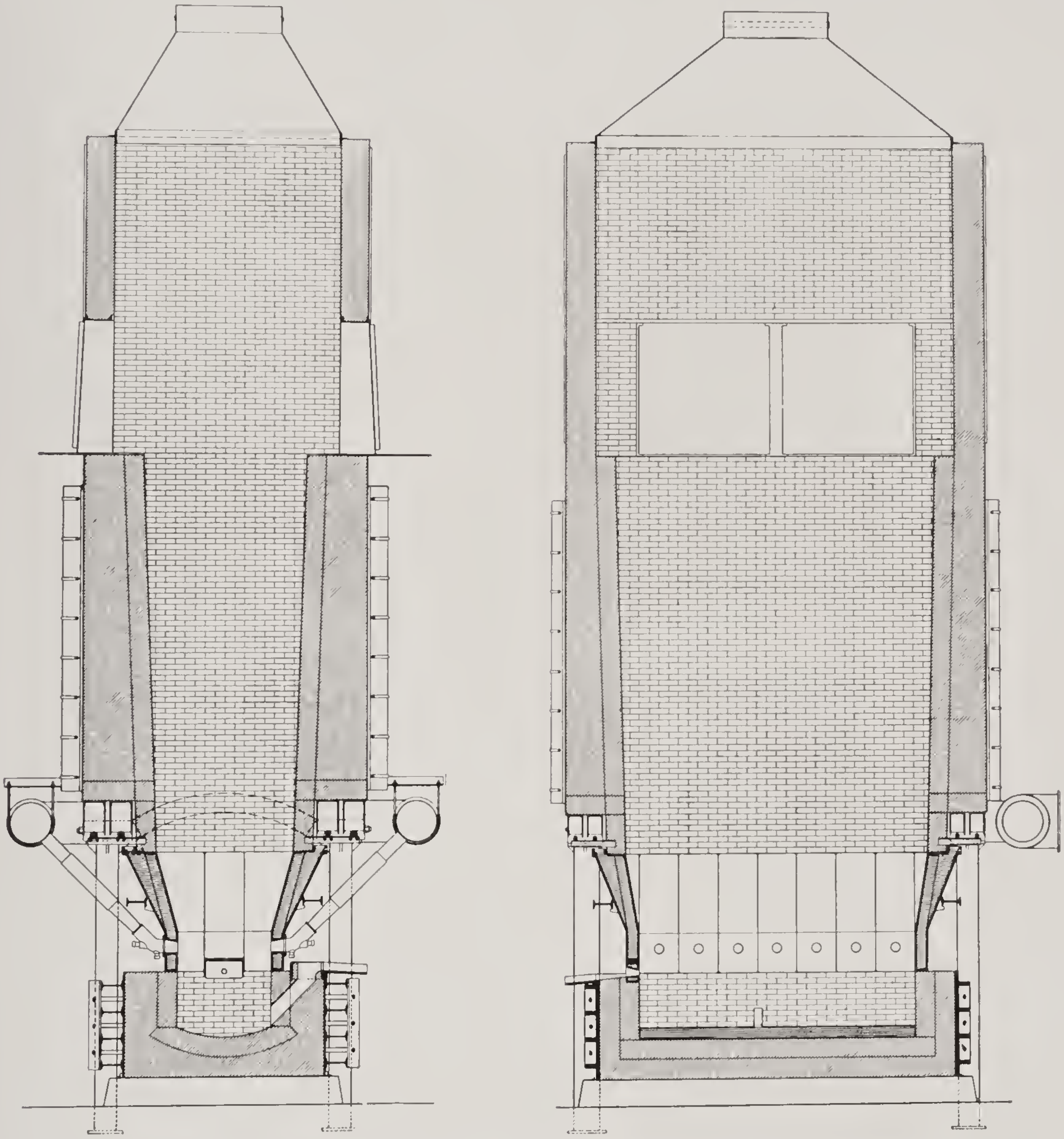


FIG. 27. RECTANGULAR SILVER-LEAD BLAST FURNACE.

tion in the United States and Mexico has served to equip us with the necessary knowledge to vary the design in minor particulars so as to secure the best results in operation under any given conditions. The duty of blast furnaces is more severe than other equipment and our success in building furnaces which prove equal to the mechanical strains to which they are subjected has contributed to our supremacy no less than our ability to design them along lines which are metallurgically correct.

Lead furnaces are built with either steel or cast iron jackets. We have developed cast iron jackets to such a point that they give really efficient service, especially so in view of their low cost; but steel jackets are better. There is a limit to the height which a jacket may be made when of cast iron, and this is not met with in the case of steel; furthermore, the steel jackets may be made wider and the water connections thereby simplified. We have built lead furnaces with cast iron lower and steel upper jackets, but usually

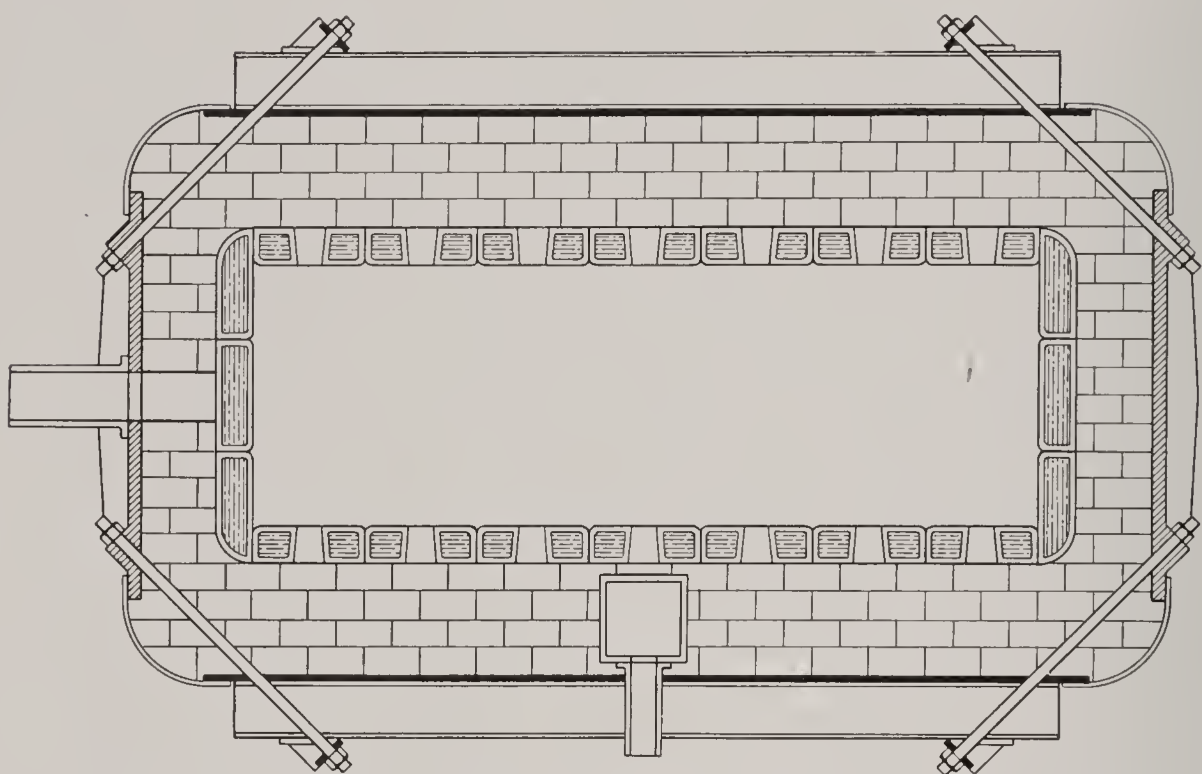


FIG. 28. PLAN OF CRUCIBLE OF LARGE LEAD FURNACES.

build them with a single tier of steel jackets where jackets of considerable height are desirable. The proper interior contour can in this case be easily secured.

On this page we show a plan of the crucible construction used in our large lead furnaces. The internal pressure is taken up by heavy, ribbed cast iron end plates connected by heavy bolts with side plates of steel reinforced with four heavy I-beams. The bolts pass through the corners of the brick-work, and curved corner plates bolted through slotted holes to the sides and ends complete the curb and permit the easing up of the main bolts to allow for expansion of the brick-work. The caissons of smaller furnaces are made of heavy cast iron plates or steel plates reinforced with T-rail as the case demands.

The caisson plates rest upon a bottom formed of steel plates which prevents the seepage of values into the foundation.

Silver-Lead Blast Furnace.

This furnace is most highly recommended where a small capacity is desired. The rectangular form is superior to the circular or polygonal, and, in addition, this furnace has been designed with special reference to facility in cleaning out, a feature of great importance in so small a unit.

The jackets are of flange steel plate and are suspended by chains from the mantel frame, permitting them to be swung out with less

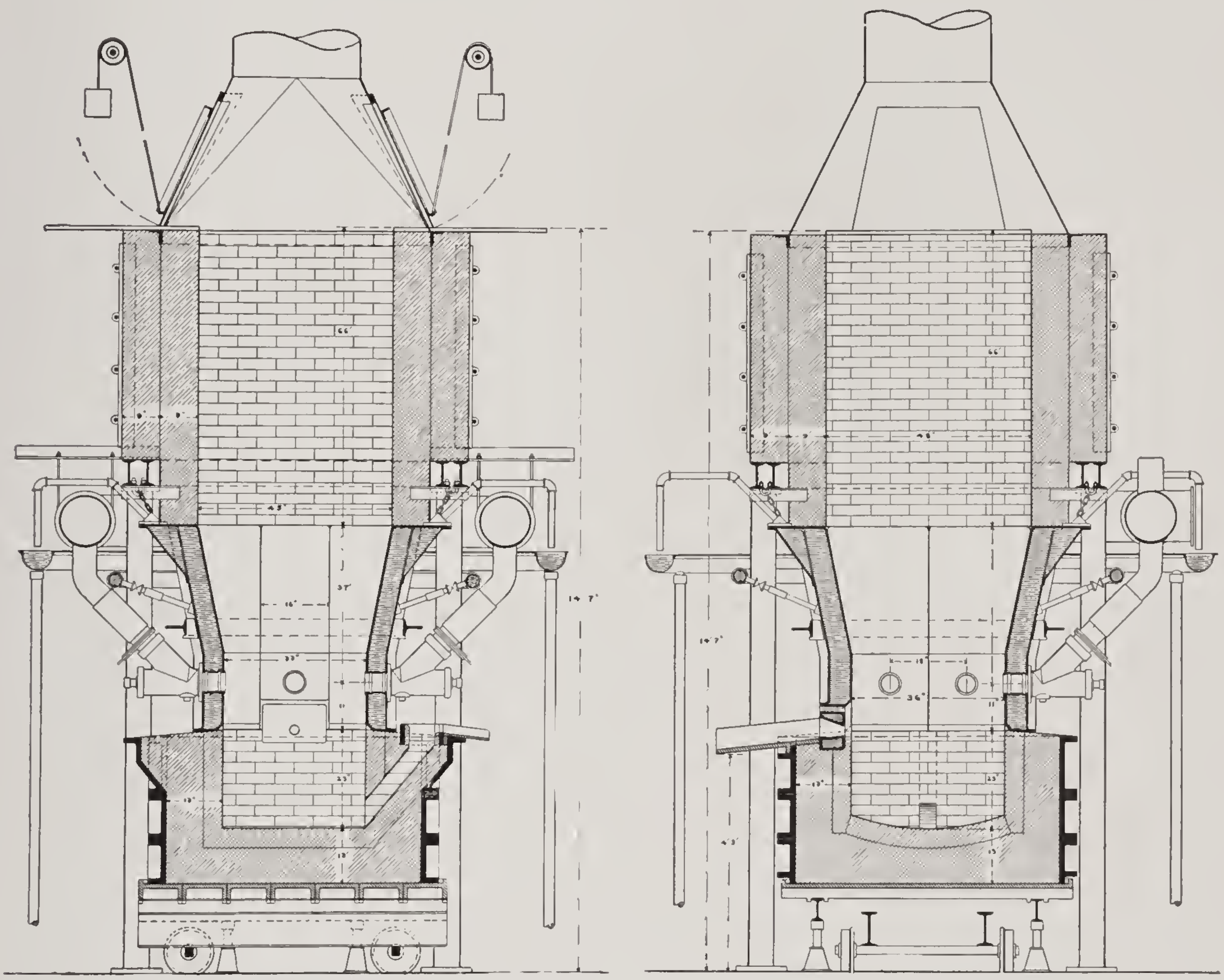


FIG 29. SMALL RECTANGULAR LEAD FURNACE.

difficulty than would be experienced in their complete removal. The blast and water piping have been so disposed as to render this easy.

The crucible is built within a caisson of cast iron plates and is normally held upward against the bottoms of the jackets by jack screws. A car is provided to receive the crucible when lowered and remove it to be cleaned out or relined as necessary. Two crucibles with cars are furnished so that with one in reserve the furnace can be cleaned out and started up again with a minimum loss of time.

The illustration shows the jackets as made for mule-back transportation. For ordinary conditions, the side and end jackets are each in one piece.

Silver-Lead Blast Furnace.

The construction illustrated on this page is the best for small round furnaces, as the jackets being made in vertical sections render it possible to secure the best interior contour.

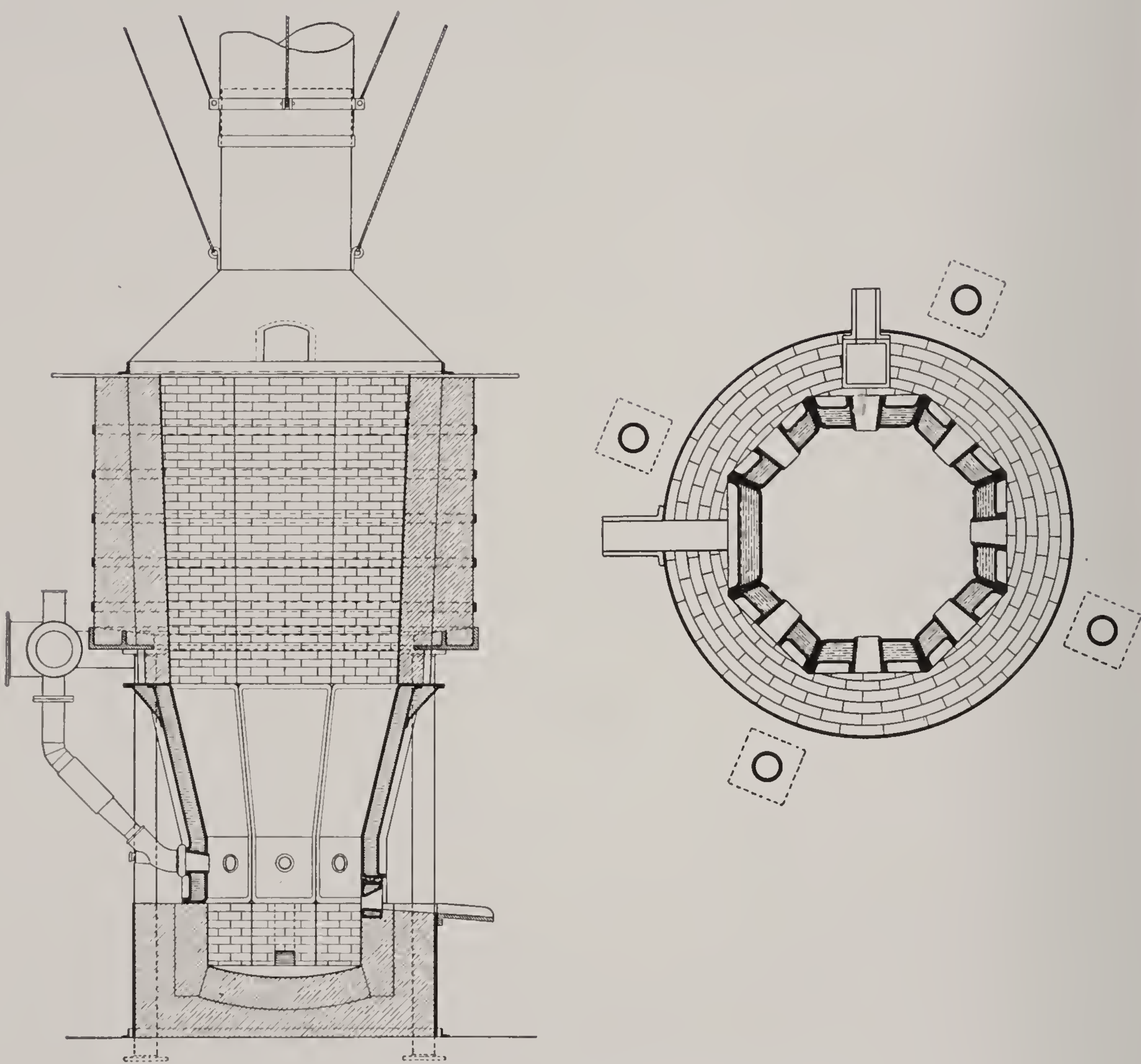


FIG. 30. POLYGONAL LEAD BLAST FURNACE.

The curb is of heavy steel plate rolled to a circle and rests on a bottom plate which prevents the seepage of metal into the foundation. The brick shaft is circular in section and is carried by a cast iron mantel ring resting on the four columns. The hood is adapted to be raised for charging and barring, the stack telescoping as this is done. We build 36-inch heptagonal and 42-inch octagonal furnaces of this design.

Silver-Lead Blast Furnace.

The advantage of a furnace built as here shown, is that the division of the jacket vertically into halves enables all seams to be flanged outward so that no rivets are exposed on the fire side. The

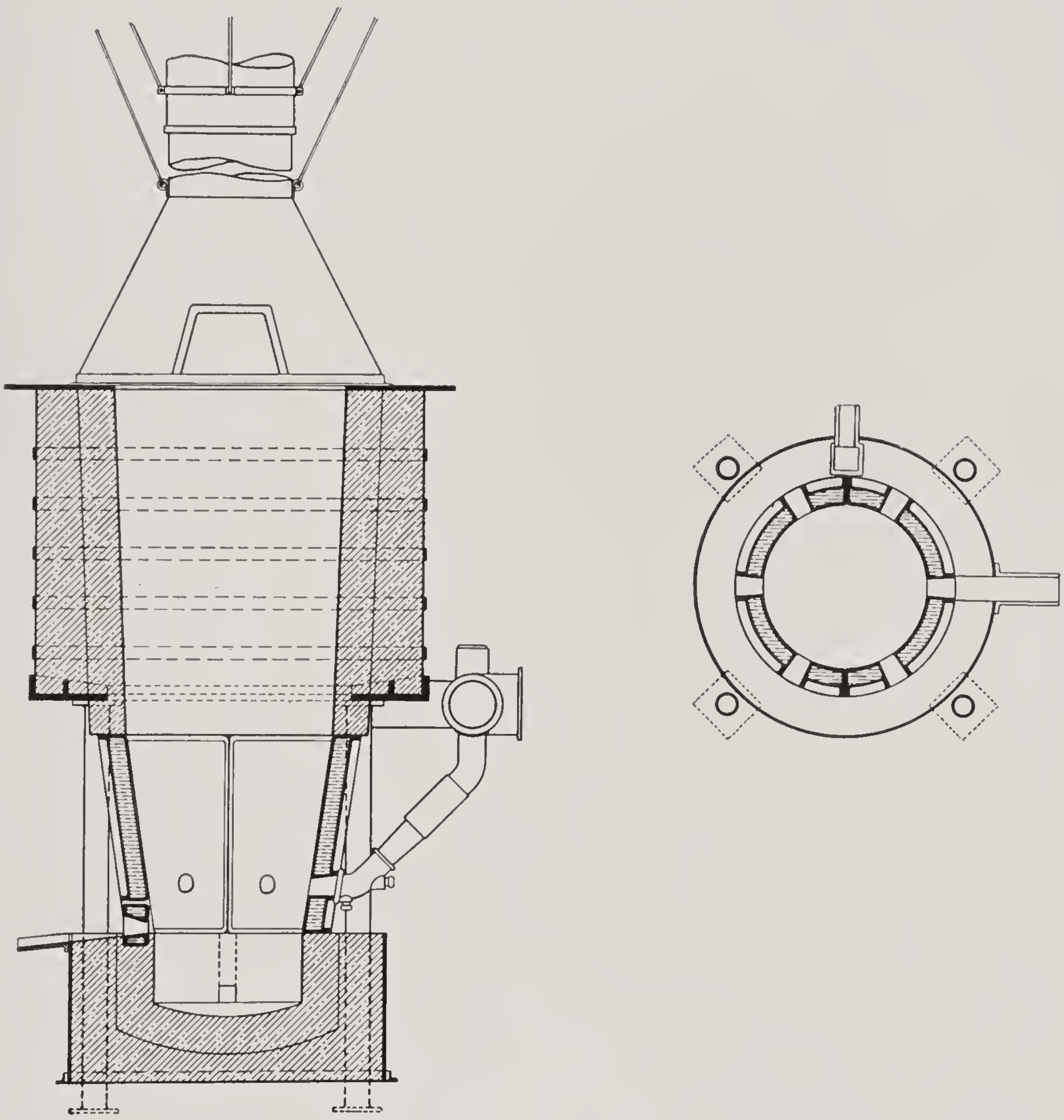


FIG. 31. ROUND SILVER-LEAD BLAST FURNACE.

jacket can also be easily removed when necessary, which is a convenience not obtainable with the jacket built in one piece.

It is inferior to our polygonal furnaces in that it has a straight bosh, but by reason of its simpler design and greater facility of construction it can be sold at a lower price.

Silver-Lead Blast Furnace.

The illustration on this page is reproduced from a photograph of one of three furnaces supplied at intervals to a large lead smelter. It is typical of the best design and construction in large lead furnaces with cast iron jackets.

The curb of the crucible is constructed with very heavy, ribbed

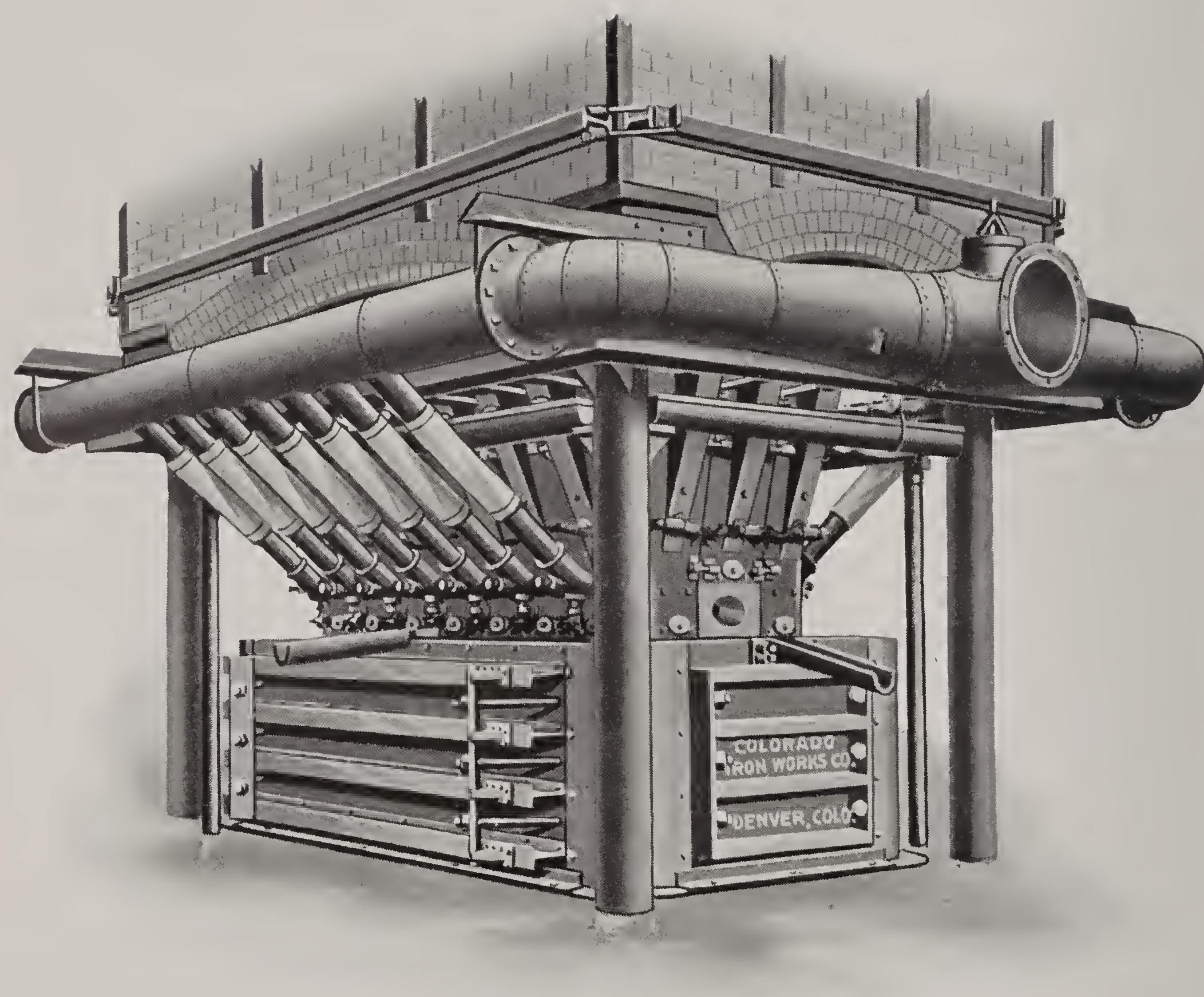


FIG. 32. 42″ x 126″ SILVER-LEAD BLAST FURNACE.

cast iron end plates, and side plates of heavy steel plate reinforced with I-beams as shown in the plan, Fig. 28. The engraving shows part of the brick shaft and the manner in which it is carried on our patent arch-bar mantels, as well as the way the brickwork is bound together.

The automatic gas escape valve which we place on all furnaces is shown on the bustle pipe at its point of connection to the blast main.

Silver-Lead Blast Furnace.

The furnace here illustrated is one of a number built by us and embodies a special means of binding the jackets. This consists of an I-beam frame carried around the furnace outside of the columns, with small jack screws between this frame and the backs of the jackets. With this construction a jacket can be removed without taking down the binder frame and without weakening the support of the jackets remaining in place.

The caisson is formed of steel plates reinforced with T-rail,

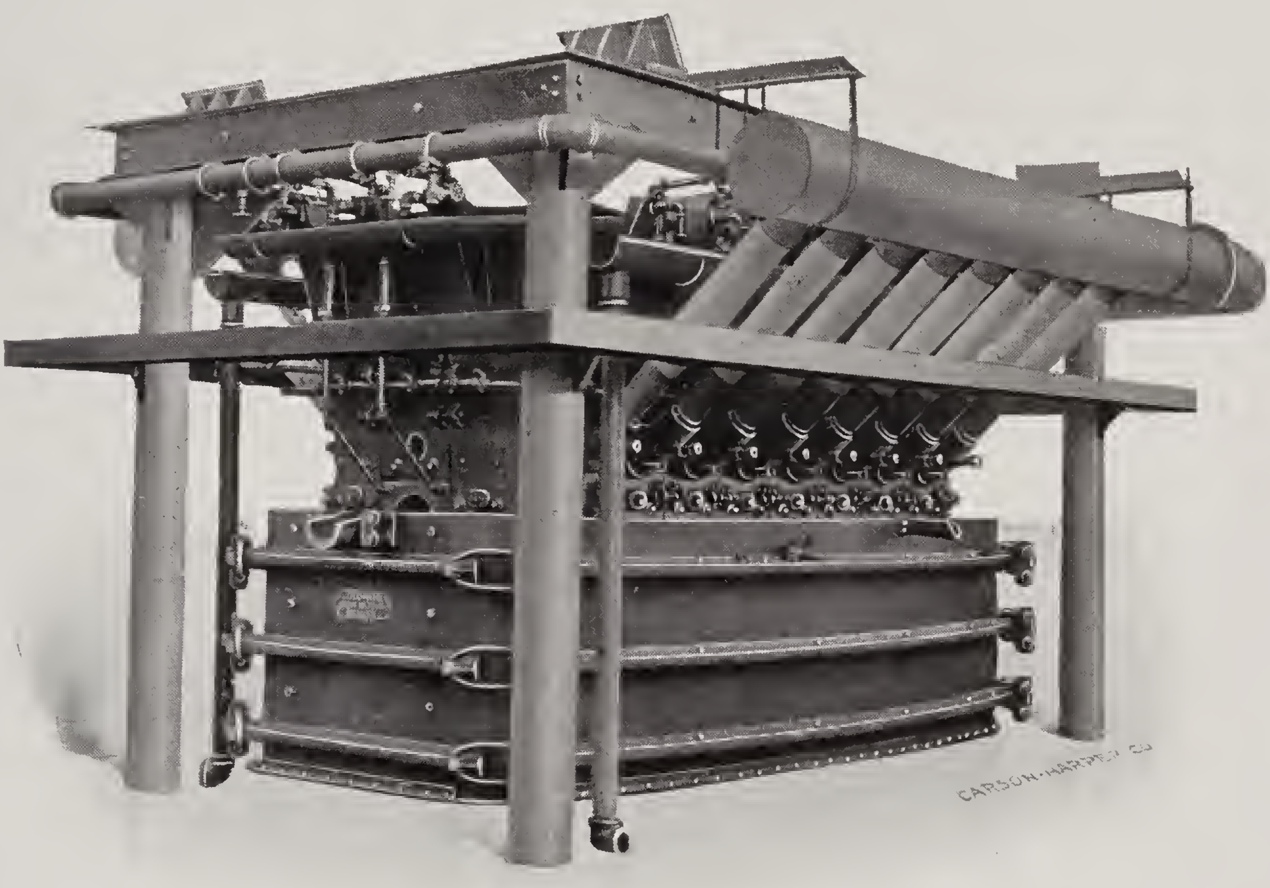


FIG. 33. 36″ x 144″ SILVER-LEAD BLAST FURNACE.

the side plates being rolled to a large radius. The mantel frame is formed of I-beams carried on the corner columns, with skew backs to take the thrust of an arch sprung over the mantels and transferring the weight of the brick shaft to the corner columns. Many furnaces are built this way, but we recommend our patent arch bar mantel construction as superior, for the reasons brought out in the description of that feature.

Silver-Lead Blast Furnace.

We here show a silver-lead blast furnace, three of which were built for a large western lead smelter. The jackets are of cast iron with our regular lead furnace tuyeres and canvas blow pipes, as is usual in furnaces of this type.

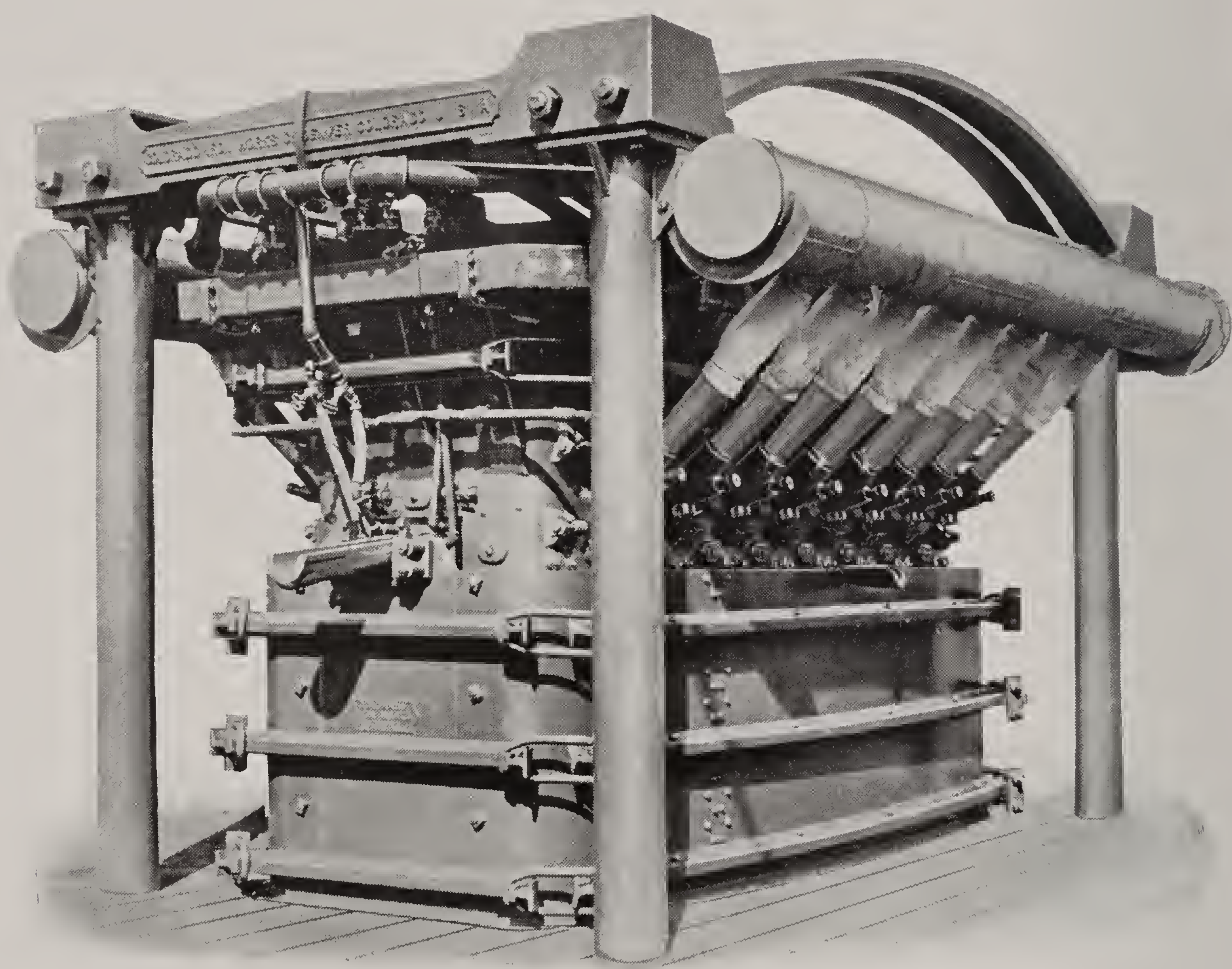


FIG. 34. 36″ x 144″ SILVER-LEAD BLAST FURNACE.

Our patent arch-bar mantels are shown on the sides of this furnace and cast iron mantels at the ends. We recommend the arch-bar mantels for both sides and ends as they have overcome the objections to all other forms.

The crucible construction is such as we have used to a great extent—steel plates reinforced with T-rail, the side plates being rolled to a curve of large radius.

Silver-Lead Blast Furnace.

This furnace has cast iron water jackets and our standard tuyeres, and is equipped with the Nesmith patent jacket water vaporizer described elsewhere in this catalogue, and which reduces the amount of water required to less than one-eighth that ordinarily

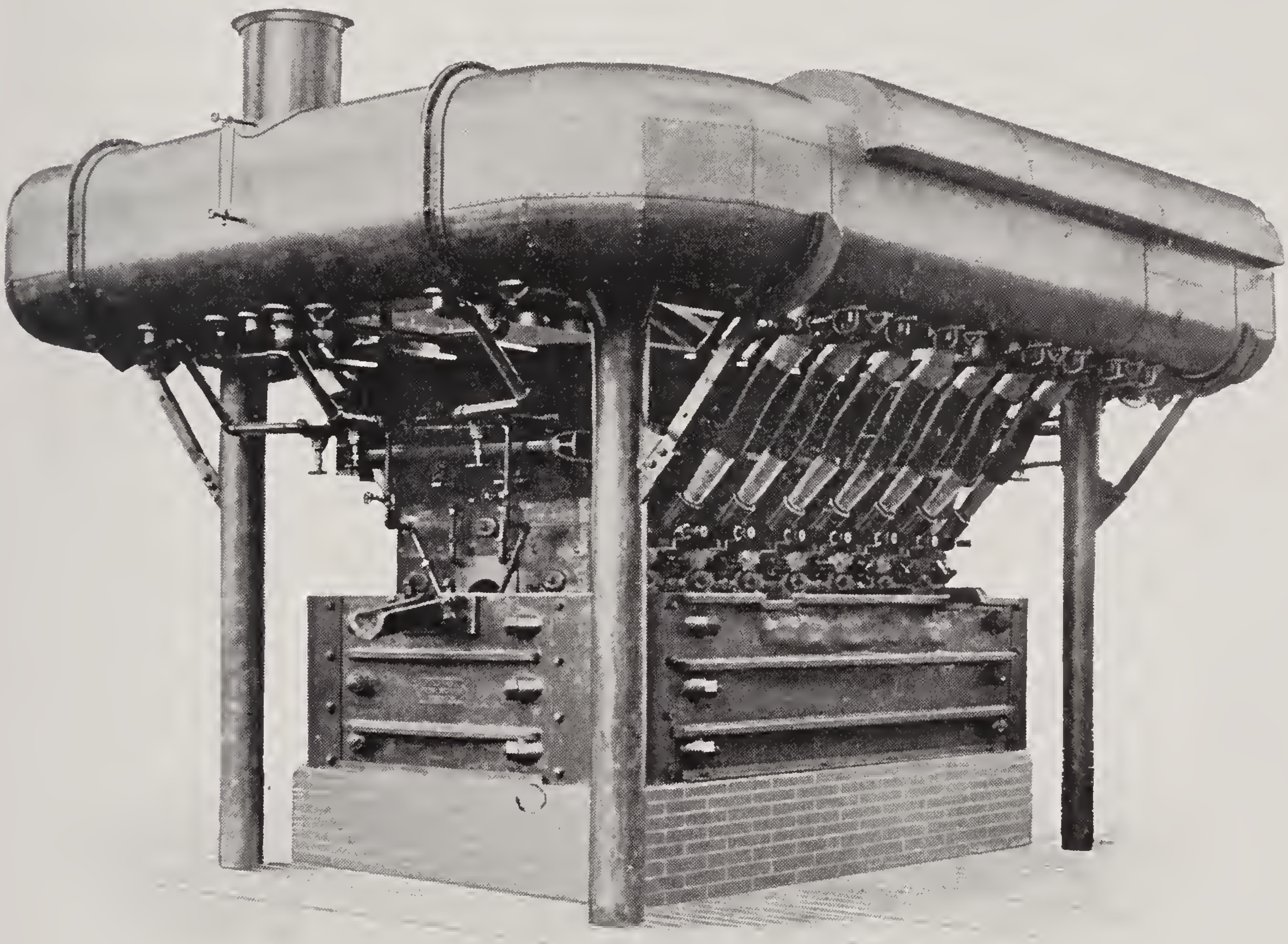


FIG. 35. 42" x 120" SILVER-LEAD BLAST FURNACE.

necessary. The bustle pipe is combined with the vaporizer drum whereby the blast is warmed and water cooled by exchange of heat.

The crucible is built within a caisson formed of heavily ribbed cast iron plates on both sides and ends, with steel corner plates bolted to them through slotted holes, allowing for expansion. Heavy bolts passing through the corners of the crucible take the strain, and a plate steel bottom prevents the foundation from becoming impregnated with lead and locking up values.

Silver-Lead Blast Furnace.

The furnace here shown is an example of our small rectangular type. The jackets are of cast iron made in the special manner developed by us, although we will build such furnaces with steel jackets if desired. This furnace has an end center jacket between the corner jackets, provided with a tuyere opening. This tuyere opening is plugged on the end where the tap hole is located, and the other end

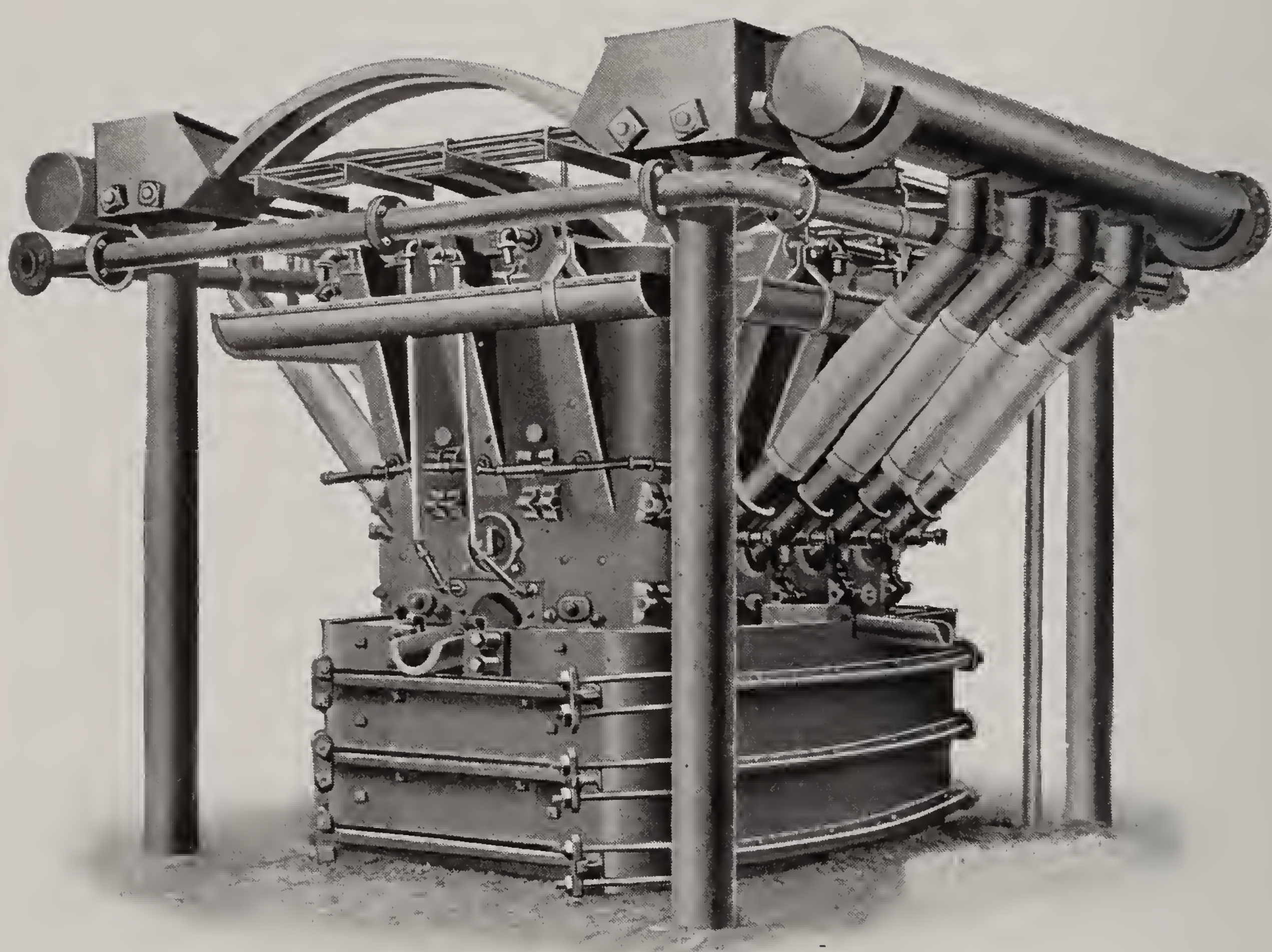


FIG. 36. 36″ x 72″ SILVER-LEAD BLAST FURNACE.

tuyere may likewise be closed if it is found unnecessary as is sometimes the case in practice.

This furnace has our patent arch-bar mantels on sides and ends so that all the weight of the brick shaft is transferred through these arches to the corner columns. The crucible caisson is made of heavy steel plate, reinforced with T-rail, ends straight and sides curved to a large radius.

Silver-Lead Blast Furnace.

This is an example of our small lead blast furnaces of recent design. The jackets are of cast iron, the corner jackets also forming the end. The end tuyere opening is half in each section, and both ends of the furnace have tuyere openings, so that a corner jacket will fit in either end of the furnace.

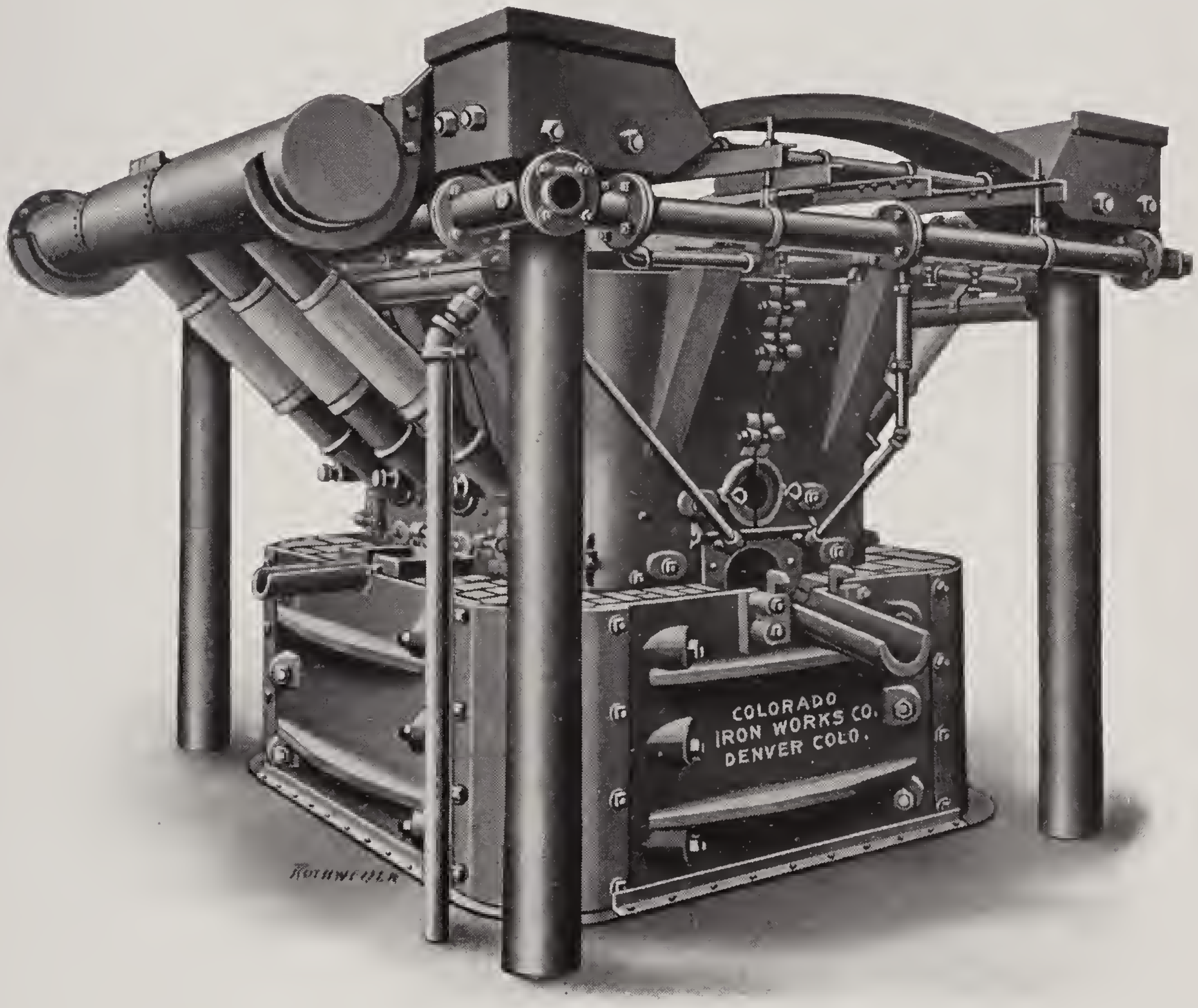


FIG. 37. 36″ x 60″ SILVER-LEAD BLAST FURNACE.

Our patent arch-bar mantel frame is shown on this furnace. The steel channel curved, and extending between the skew backs carries the brick shaft, and the short pieces of angle iron extending inward and fastened to the stay rods carry the fire brick lining.

The caisson plates are of cast iron made very heavy and a plate steel bottom prevents seepage of values into the foundation.

Silver-Lead Blast Furnace.

For small capacities, a small rectangular furnace is superior to a round one, and we recommend the rectangular furnace notwithstanding the fact that the erected cost is somewhat greater by reason of the brick shaft and superstructure. The furnace here shown is of as inexpensive construction as possible, without sacrificing either material or workmanship, and is a good one to smelt the product of

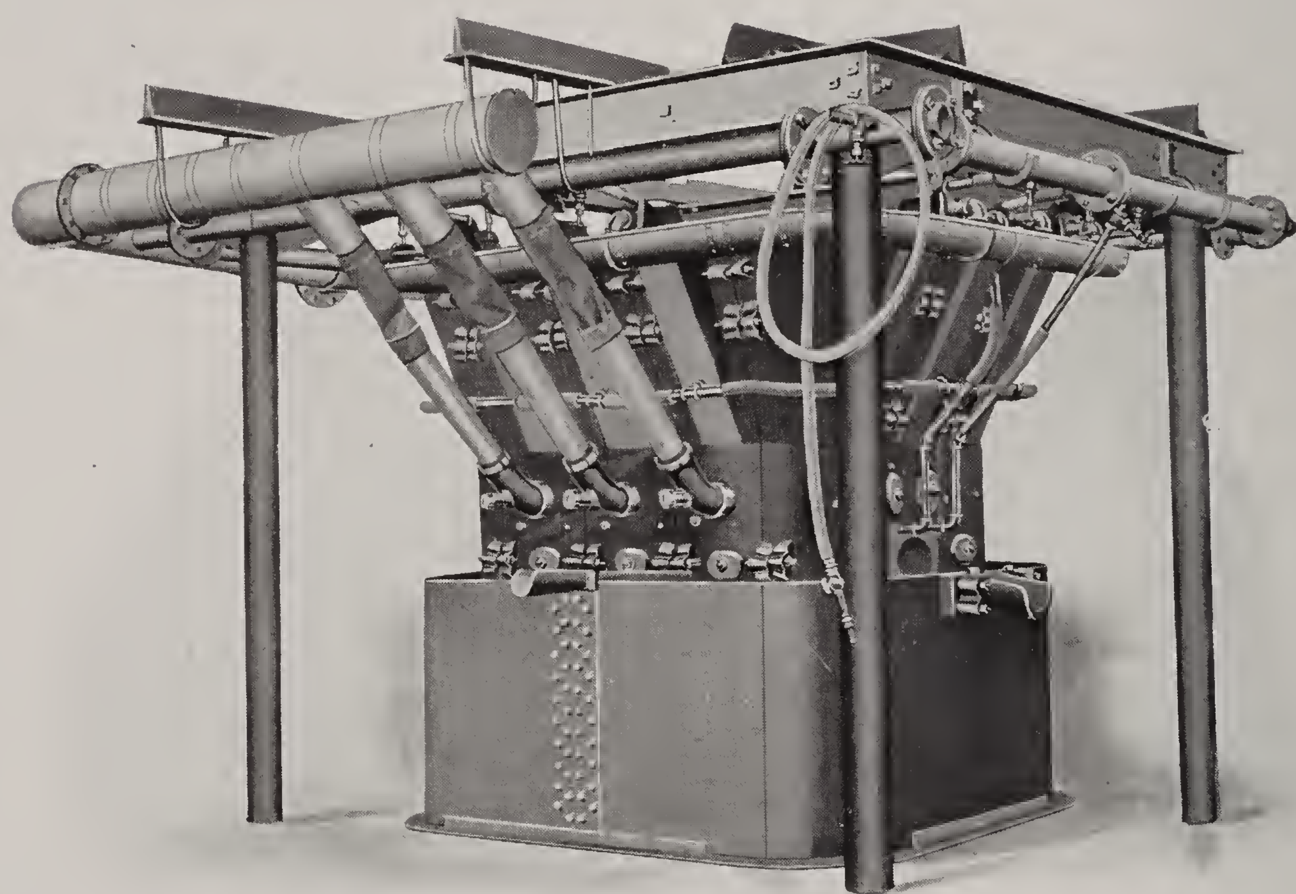


FIG. 38. 36″ x 51″ SILVER-LEAD BLAST FURNACE.

a small mine, where it is desired to have the outlay as small as possible.

This furnace has the ordinary I-beam mantel frame carried upon the four corner columns with skew backs from which relieving arches are sprung. The crucible is surrounded by a curb of heavy steel plate conforming in shape to the furnace and with rounded corners.

Silver-Lead Blast Furnace.

The furnace shown on this page is sectionalized for mule-back transportation, no single part weighing over 300 pounds. To meet the requirements as to maximum weight of parts, the jackets were made in sections twelve inches wide, the furnace thus comprising fourteen jackets.

The interior contour of this furnace is the same as our larger

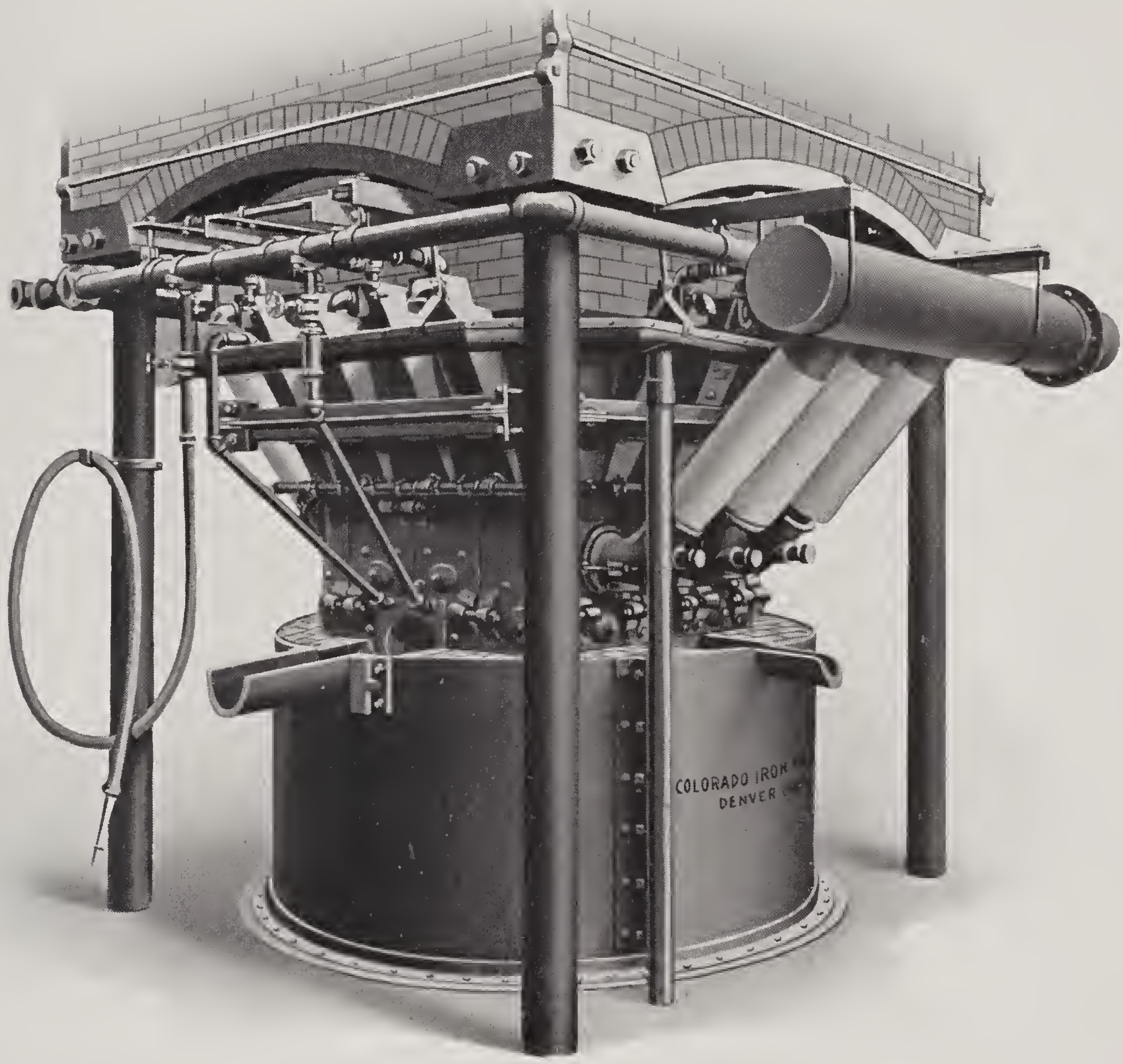


FIG. 39. 30″ x 36″ SECTIONALIZED LEAD FURNACE.

rectangular furnaces and it is in every way suitable for producing metallurgical results equal to any furnace of its size, and when erected the only disadvantage over a similar furnace not sectionalized is the more numerous water connections.

The curb of the crucible is in sections ready to be bolted together, the bed plate being shipped in halves to be riveted together on the ground. The furnace was built with our patent arch-bar mantel frame, the supporting columns being of five-inch extra heavy steel pipe.

Silver-Lead Blast Furnace.

This furnace was the first one supplied to a customer in a remote locality and was operated for a long time before the construction of a wagon road permitted the transportation of a larger furnace of regular construction. Subsequently both furnaces have been kept in operation.

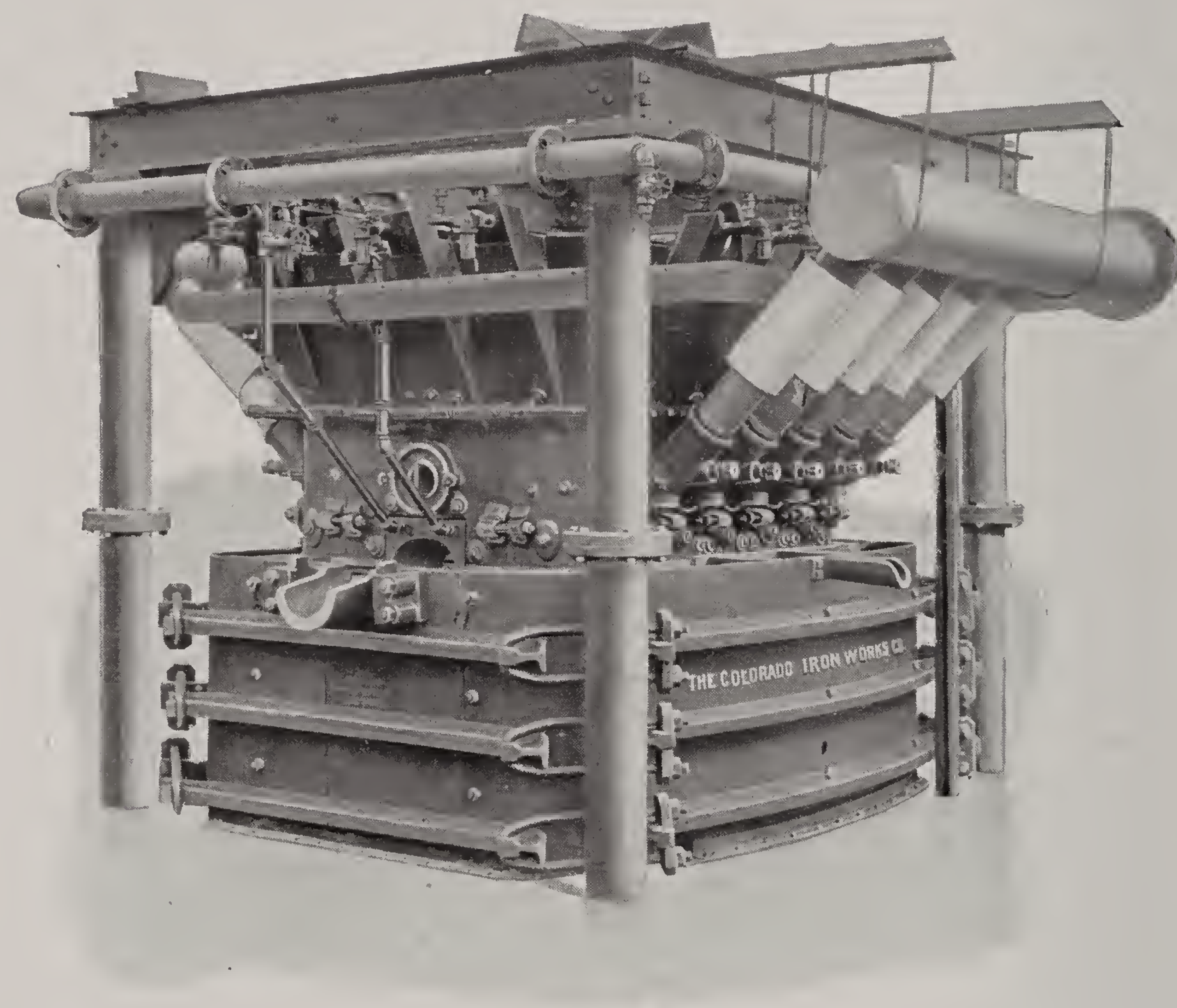


FIG. 40. 36″ x 60″ SECTIONALIZED LEAD FURNACE.

Aside from the more numerous water connections due to the greater subdivision of the jackets, there is no disadvantage in a furnace of this kind when erected. The first cost is, however, somewhat higher than one of regular construction.

Special care is taken in both design and manufacture of our sectionalized furnaces to simplify and reduce as far as possible the amount of work to be done at destination, as we realize the difficulties under which such work is often performed.

The corner columns are in halves to bring the parts within the required weight and the mantel frame is of I-beams although we are now supplying our patent arch-bar mantels.

Silver-Lead Blast Furnace.

The illustration on this page is reproduced from a photograph of one of three lead blast furnaces built for an important smelter. It represents the best type of construction throughout and is built for hard service.

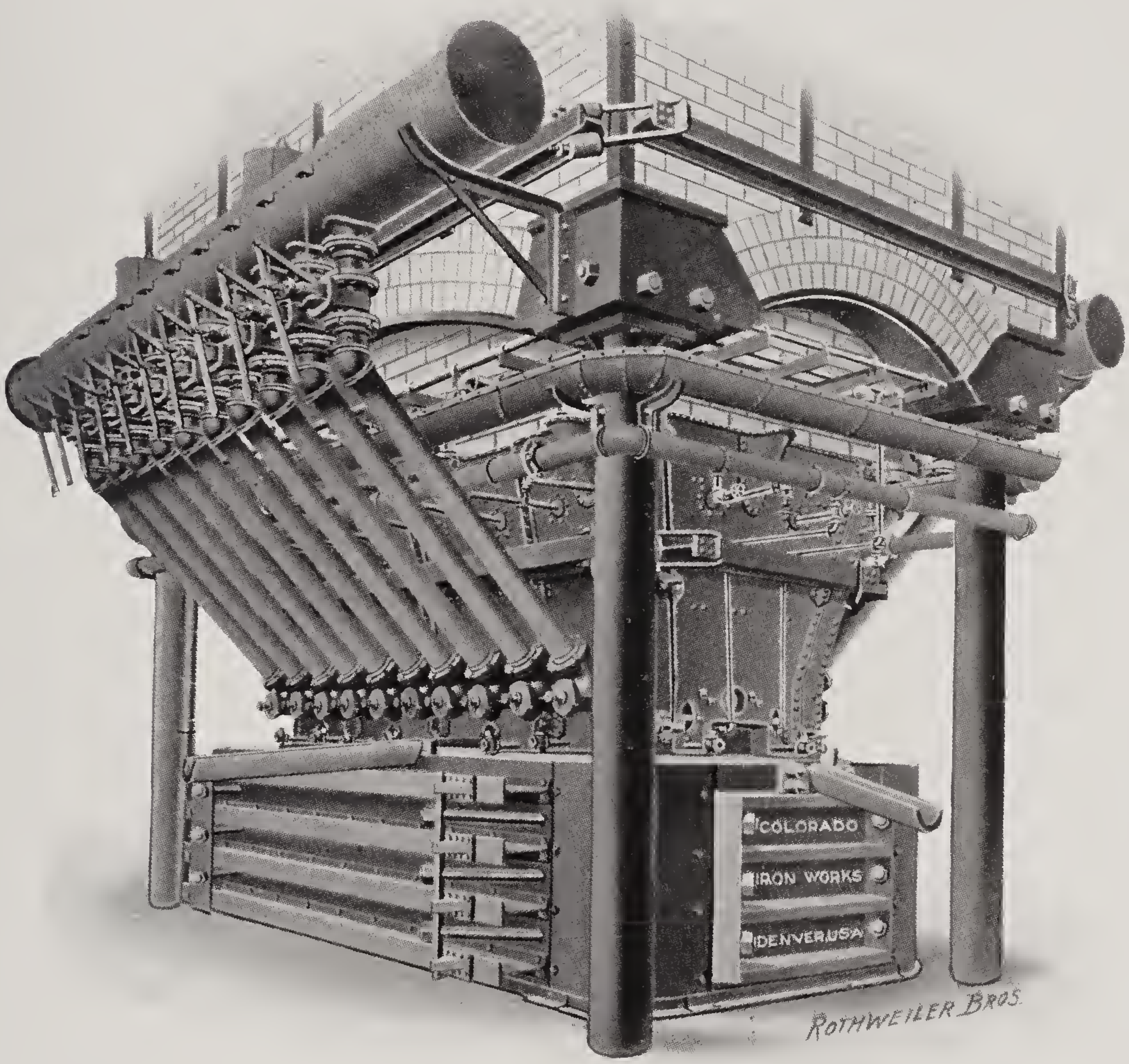


FIG. 41. 42″ x 160″ SILVER-LEAD BLAST FURNACE.

The jackets are of flange steel, the tuyeres have the blast inlet at 45 degrees with blow pipes of standard pipe and individual gate valves placed under the bustle pipe. The caisson is of the best construction, with cast iron ends and steel sides reinforced with I-beams.

The brick shaft is shown, resting upon our patent arch-bar mantels and the manner in which the fire brick lining is carried by the inwardly projecting angle irons can readily be seen. The manner of binding the brick shaft between the mantel frame and the feed floor is also indicated.

Silver-Lead Blast Furnace.

This furnace is built with flange steel jackets and is of first class construction. Steel jackets not only are longer lived than cast iron, but are made in larger sections, thereby reducing the number of water connections. Both end jackets are alike and interchangeable, the one used on the front end has the tuyere opening plugged, while the one on the back end has the opening for the tap jacket bricked

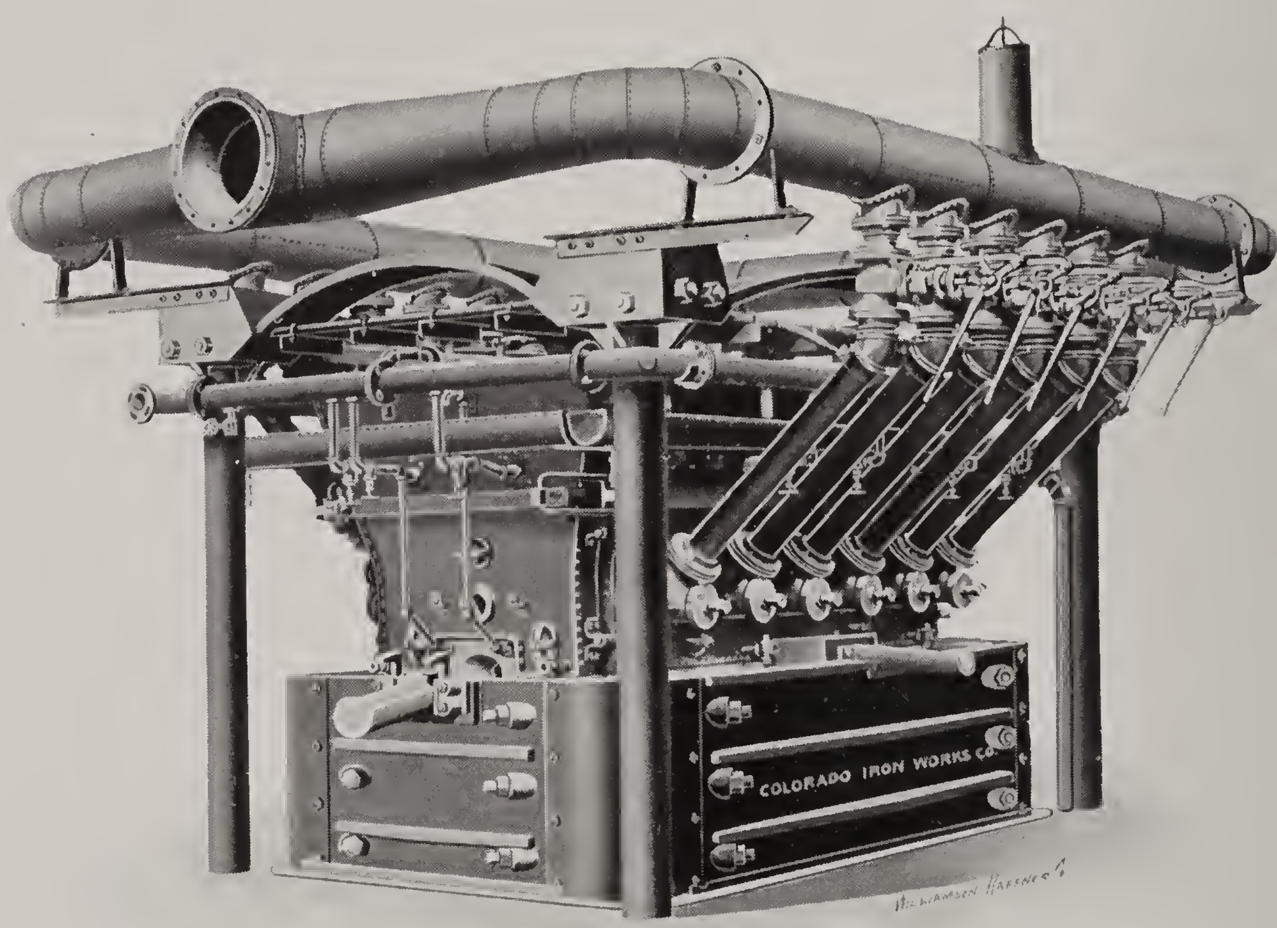


FIG. 42. 36″ x 108″ SILVER-LEAD BLAST FURNACE.

up, this offering the advantage of a point of access to the furnace in an emergency.

This furnace has our patent arch-bar mantel construction. The caisson is formed of very heavy ribbed cast iron plates and rests upon a plate steel bottom which prevents the seepage of metal into the foundation. Each tuyere has its individual gate valve, located just below the bustle pipe and the blow pipes are made of standard steel pipe.

Silver-Lead Blast Furnace.

This furnace was designed for severe duty under adverse conditions as to zinc and sulphur contents of the charge to be smelted, and two similar furnaces have been supplied by us to the same company at intervals since the first was placed in operation.

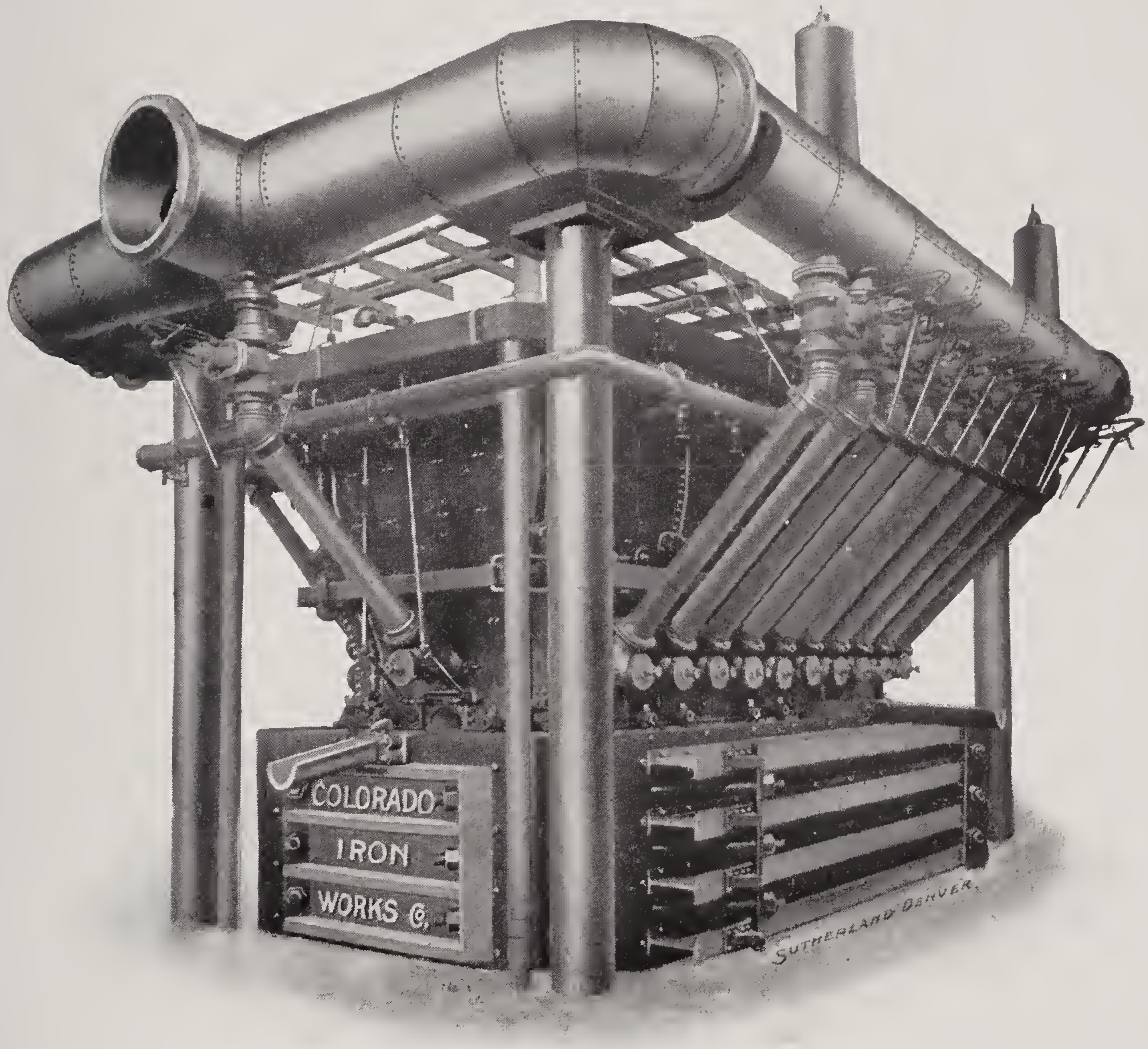


FIG. 43. 42″ x 160″ SILVER-LEAD BLAST FURNACE.

The jackets are of flange steel plate of extra height with the same interior contour as would be obtained by two tiers of cast iron jackets. The caisson is very heavy and the brick shaft stayed and stiffened in a most thorough manner. With this furnace a portable steel hood was used, giving access to the entire shaft for barring down accretions.

Silver-Lead Blast Furnace.

The furnace here illustrated is one of three built for a large plant to replace equipment long in continued use. The measures adopted to resist the internal pressure of the crucible in a furnace of such extreme size are well shown in the engraving.

These furnaces embodied the best ideas throughout and may be expected to give many years' service in continuous operation. Each tuyere is connected with the bustle pipe by standard steel pipe, and

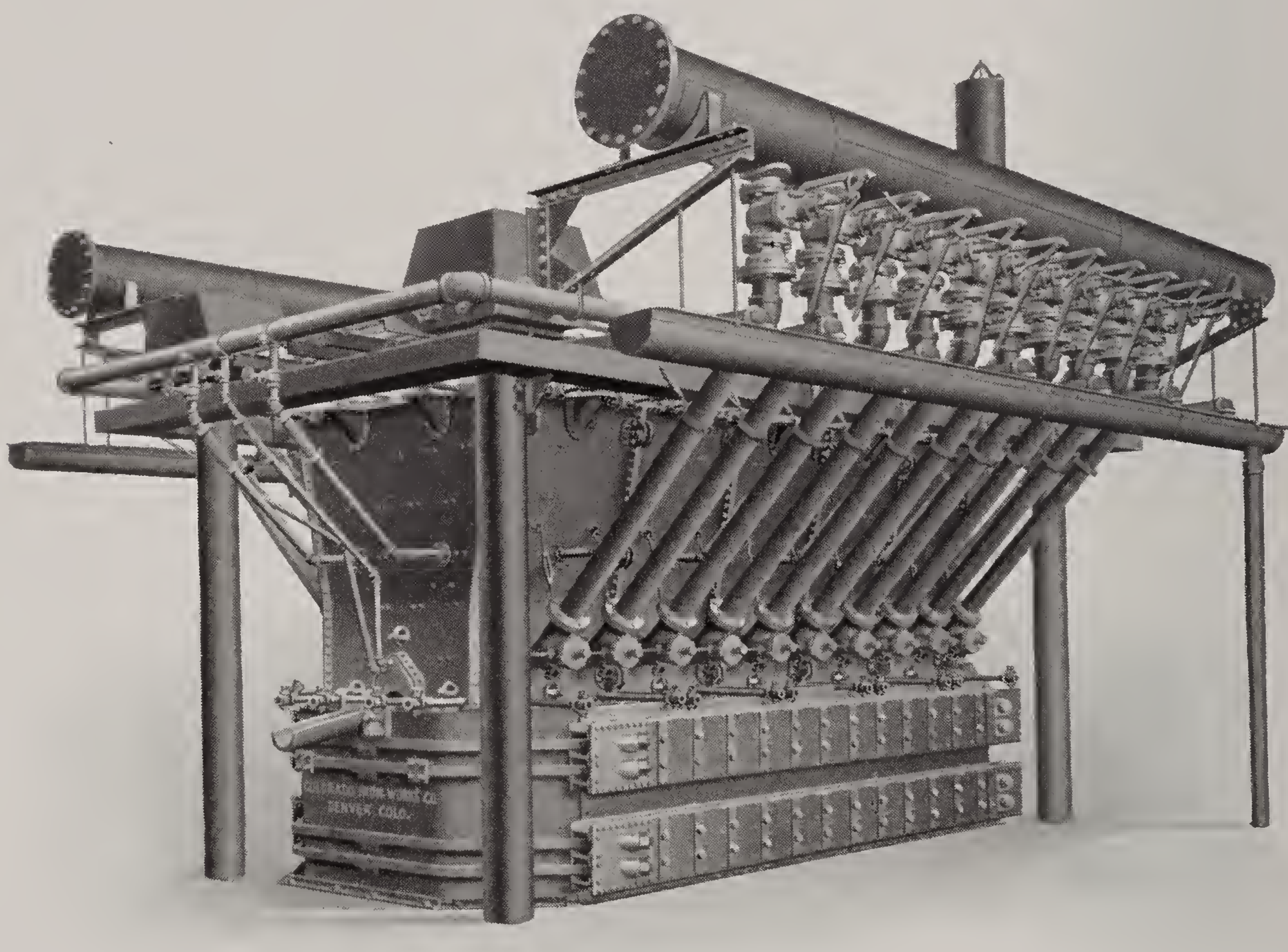


FIG. 44. 44″ x 180″ SILVER-LEAD BLAST FURNACE.

each blow pipe is provided with a quick opening gate valve permanently attached to the bustle pipe, giving individual control of the blast.

The jackets are of flange steel plate, of the best possible design and construction, and are held in position against the outward thrust of the charge at their tops by jack screws carried by a very heavy I-beam binder frame. This construction facilitates the removal of jackets, which has been further simplified by an unusual width of the upper part of the furnace. Our automatic gas escape valve can be very plainly seen in the illustration.

Silver-Lead Blast Furnace.

A very recently designed lead blast furnace is shown on this page. It is of the heaviest and most substantial construction, and was built for a mining property where a smaller furnace had been successfully operated and where it was desired to replace the blast furnace with one of the most perfect construction.

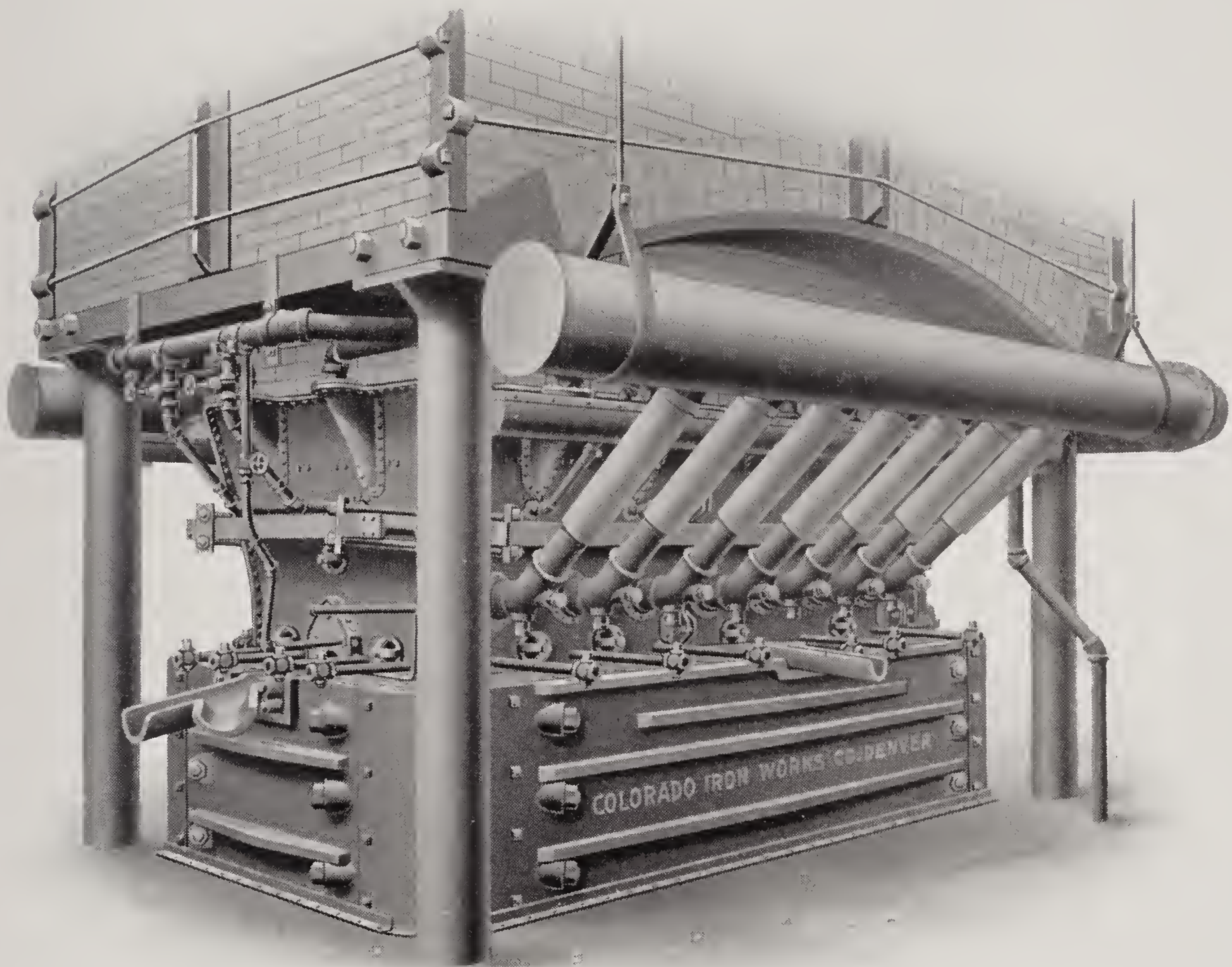


FIG. 45. 36″ x 120″ SILVER-LEAD BLAST FURNACE.

The design follows our standard lines for first-class lead furnaces, and is one that we do not hesitate to recommend. The caisson is of cast iron, very heavy, and built in accord with our regular practise whereby expansion of the crucible can be taken care of. The jackets are of flange steel plate and the tuyeres of our standard lead furnace type with canvas blow pipes which have proved very satisfactory. A portion of the brick shaft is shown in the illustration to exhibit the construction between the tops of the jackets and the feed floor.

Silver-Lead Blast Furnace.

This furnace has flange steel jackets with our regular lead furnace tuyeres and canvas blow pipes, and is equipped with the

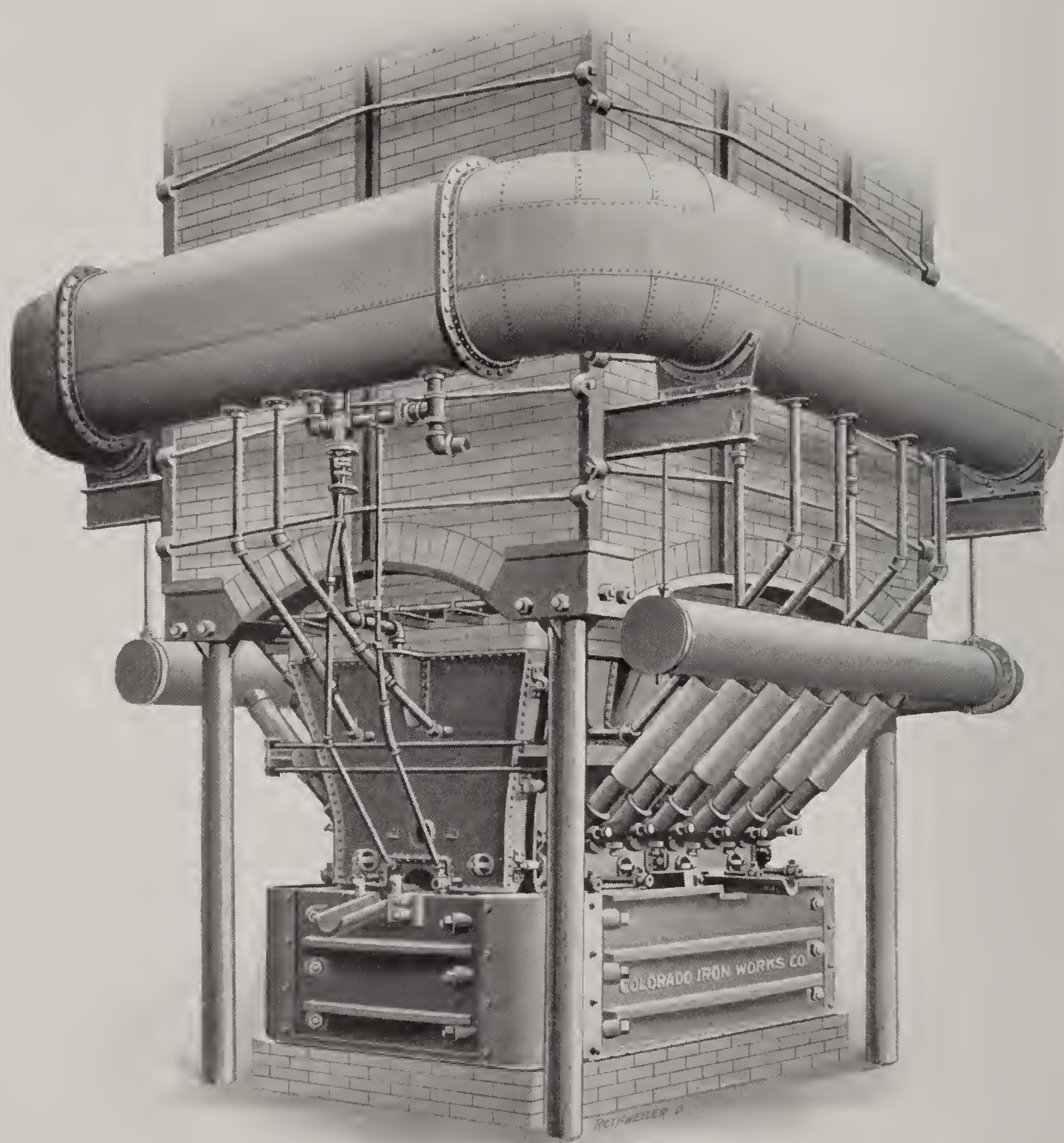


FIG. 46. 42″ x 108″ SILVER-LEAD BLAST FURNACE.

Nesmith patent jacket water vaporizer. The illustration well shows the brick shaft, arch-bar mantels, and the manner in which the vaporizer is supported by beams built into the end walls of the shaft.

The vaporization system not only saves water and dispenses with the attention necessarily given to the jacket water when the overflow system is used, but is the best method of cooling under all conditions.

Silver-Lead Blast Furnace.

The photograph here reproduced is of a round furnace sectionalized for transportation on mule back. This furnace has flange steel jackets in ten sections, which, when assembled, give a correct interior contour. Owing to the difficulty of keeping small furnaces in operation, proper interior lines are of just as much importance as in large furnaces.

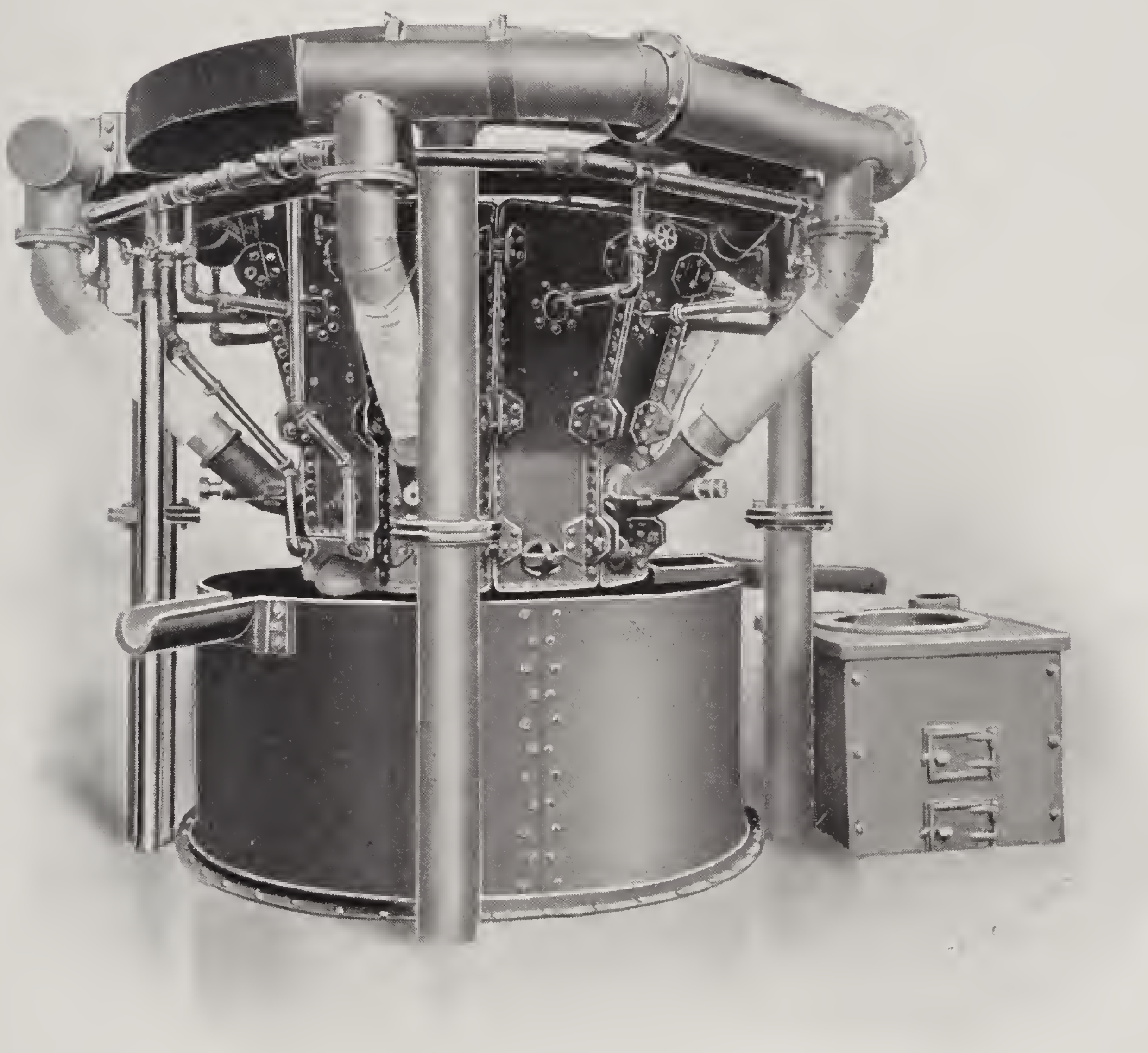


FIG. 47. 36″ SECTIONALIZED DECAGONAL LEAD FURNACE.

The caisson is round, and formed of steel plates, and rests upon a bottom plate to prevent the working of metal down into the foundation. The columns are made in halves to bring them within the weight restrictions, and support the circular cast iron mantle frame upon which the brick shaft is erected.

The tap jacket and spout are shown at the left, and at the right the lead well, a lead cooler standing beside the furnace.

Copper Matting Furnaces.

On this page is shown a 42 x 120 inch copper matting furnace of our standard type, with two tiers of steel water jackets. An auxiliary tap jacket and spout are provided in one side of the furnace for emergency use.

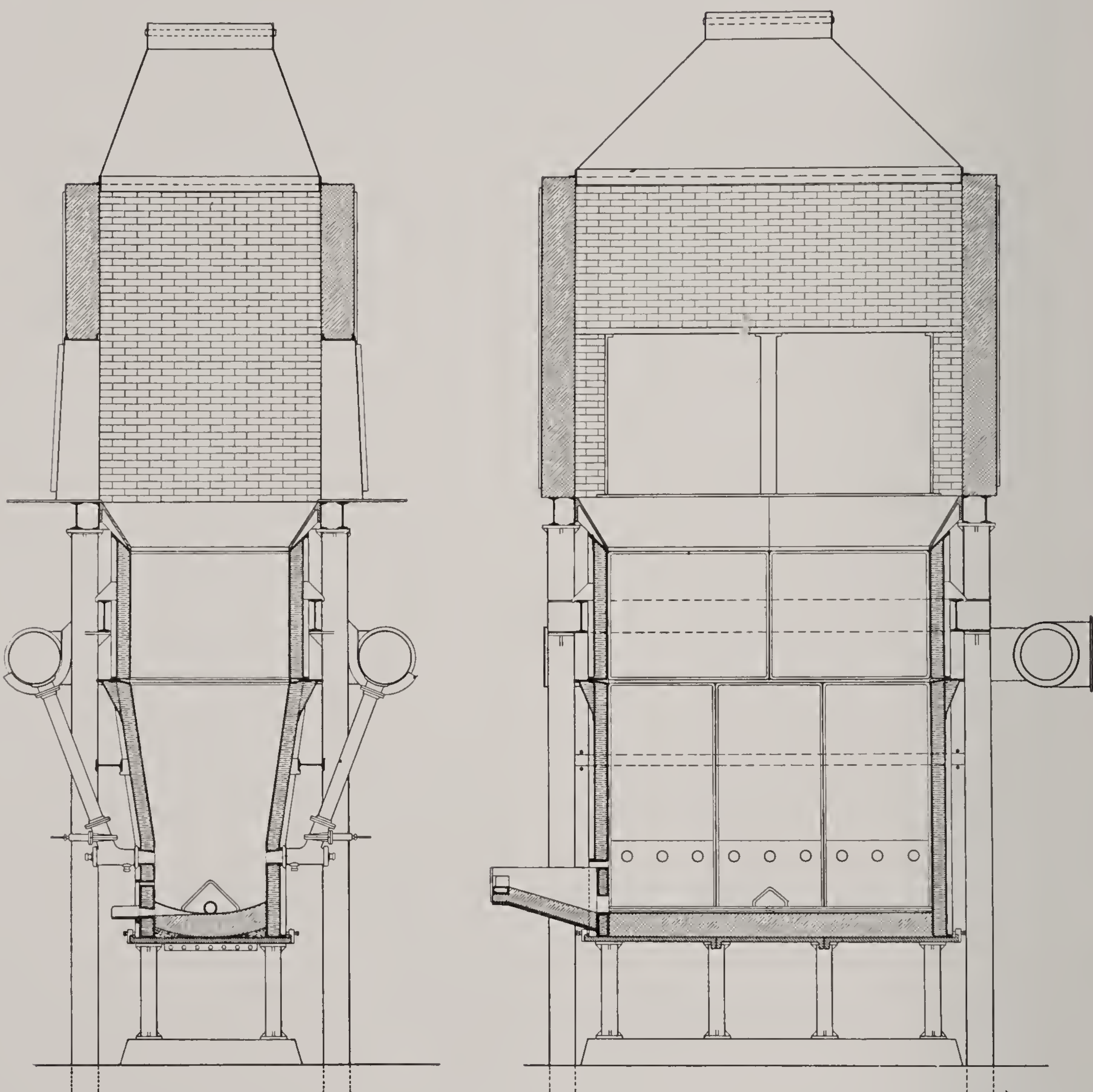


FIG. 48. COPPER MATTING FURNACE WITH TWO TIERS OF JACKETS.

The space between the tops of the jackets and the feed floor, instead of being filled with fire brick, is closed by a cast iron beveled frame extending entirely around the furnace on the inside of the steel mantel frame, thereby eliminating all brick-work below the feed floor, except that in the hearth.

Copper Matting Furnace.

Below we show a 42 x 120 inch copper matting furnace of late design along standard lines, in which the jackets extend continuously from hearth to feed floor.

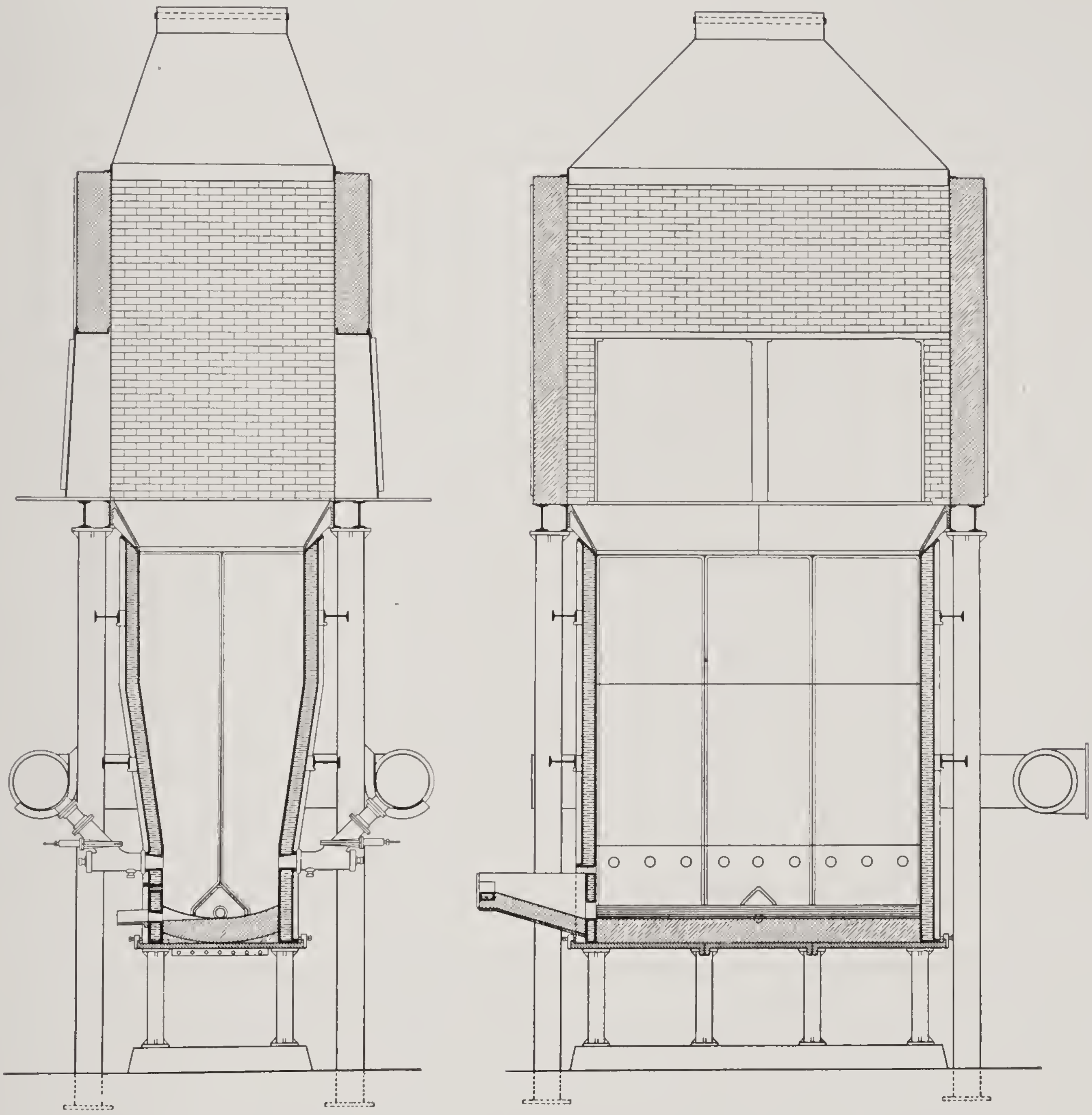


FIG. 49. COPPER MATTING FURNACE WITH A SINGLE TIER OF JACKETS.

This type offers advantages in that there is but one point at which sediment can collect, and that is below the slag and matte level, and in a simplification of the jacket water connections. In other respects this furnace is similar to the one having the jackets in two tiers.

Copper Matting Furnace.

The furnace here shown is a 42 x 240 inch copper matting blast furnace with jackets made without the knee bosh, and without outside support, depending upon their own strength and stiffness to resist the outward pressure of the charge between the bottom plate and feed floor.

In this construction the jackets are heavy and are strongly reinforced by vertical tees of large section making them extremely stiff. Furnaces of this type are largely used in Arizona, and while the

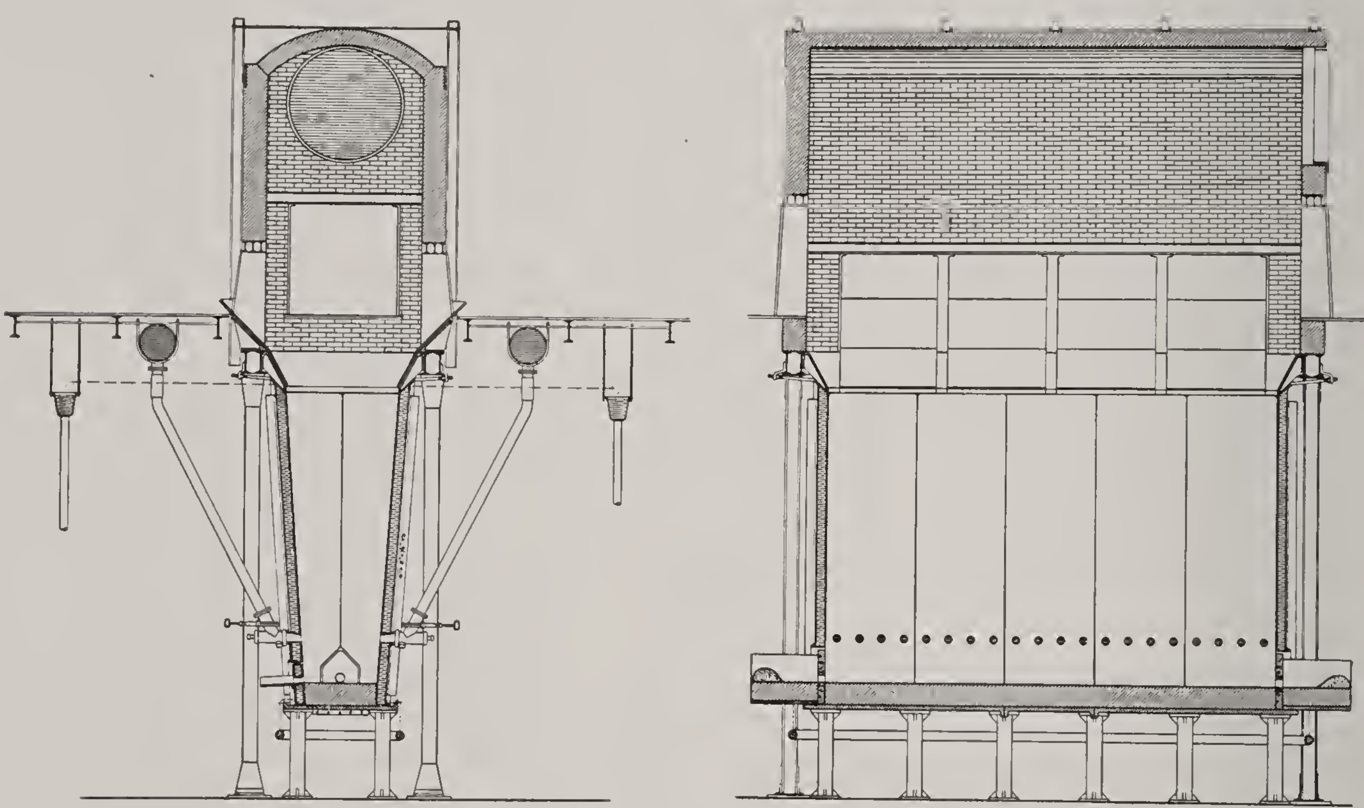


FIG. 50. COPPER MATTING FURNACE WITH SELF-SUPPORTING JACKETS.

jackets distort more than smaller ones braced as in our standard designs, they are nevertheless considered satisfactory by those using them and offer certain advantages in ease of replacement, as well as in a reduced number of water connections.

A practise which also finds favor in the southwest is the working of the furnace into the building structure in such manner as to become practically a part of it. This enables the blast and water piping and the overflow gutters to be carried independently of the furnace structure, providing a large amount of space between and around these parts. The manner in which these features are carried out is also indicated in the above illustration.

Copper Blast Furnace.

The furnace shown below is 42 x 120 inches, and is designed along standard lines but with a crucible for smelting oxidized or carbonate ores to black copper or sulphide ores to a high grade matte where it is preferable to make inside separation.

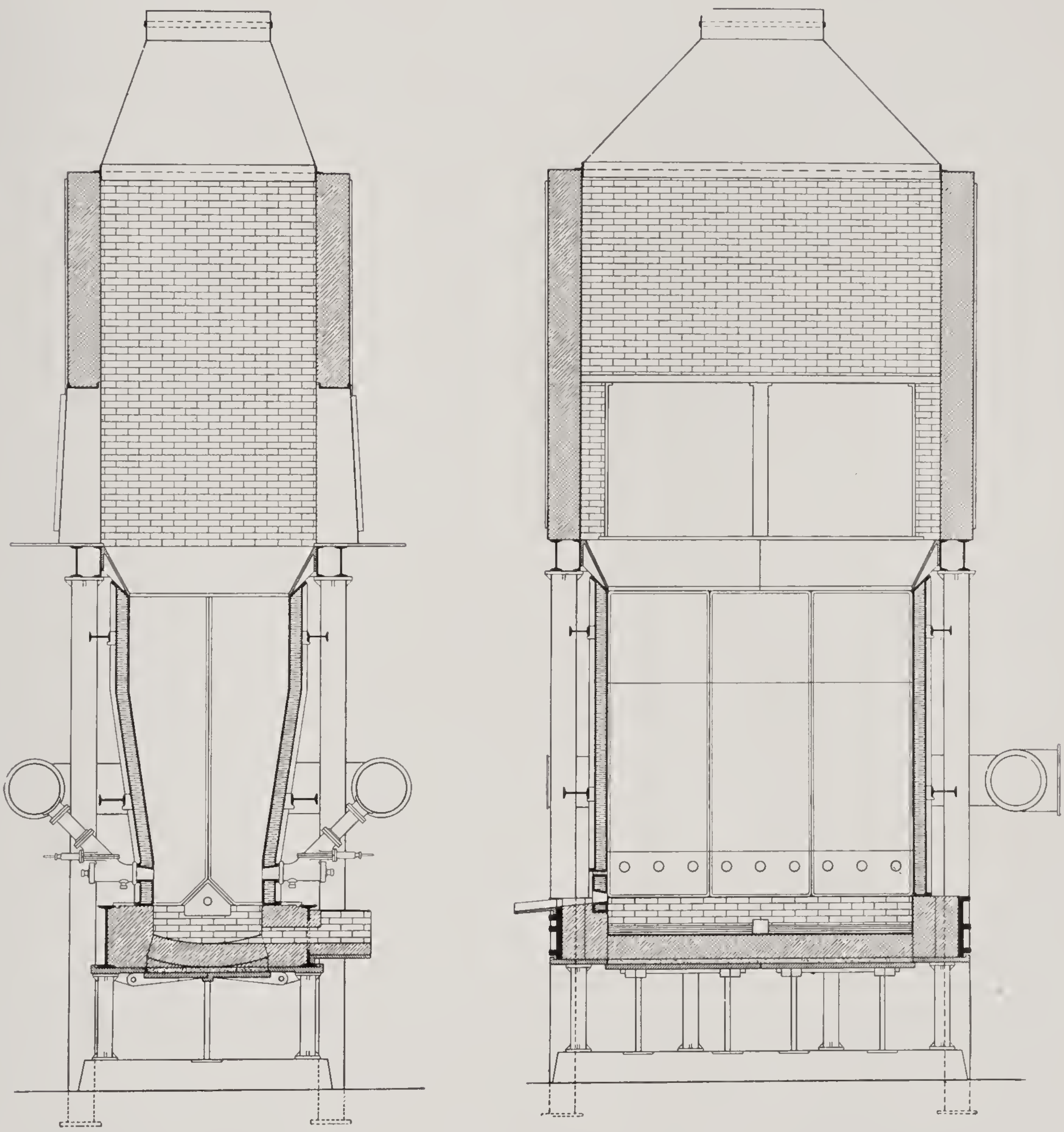


FIG. 51. COPPER FURNACE WITH CRUCIBLE FOR INSIDE SEPARATION.

We have built furnaces for such ores with jackets about 72 inches high and with brick shaft from the tops of the jackets to the feed floor as in a lead furnace; we do not, however, recommend this construction for regular copper matting.

Copper Matting Furnace.

Below is shown a copper matting furnace in which the blast enters through an air jacketed hood, whereby its temperature is raised to some degree. It has been found in actual practice that by so warming the air blast the furnace to an extent will operate auto-

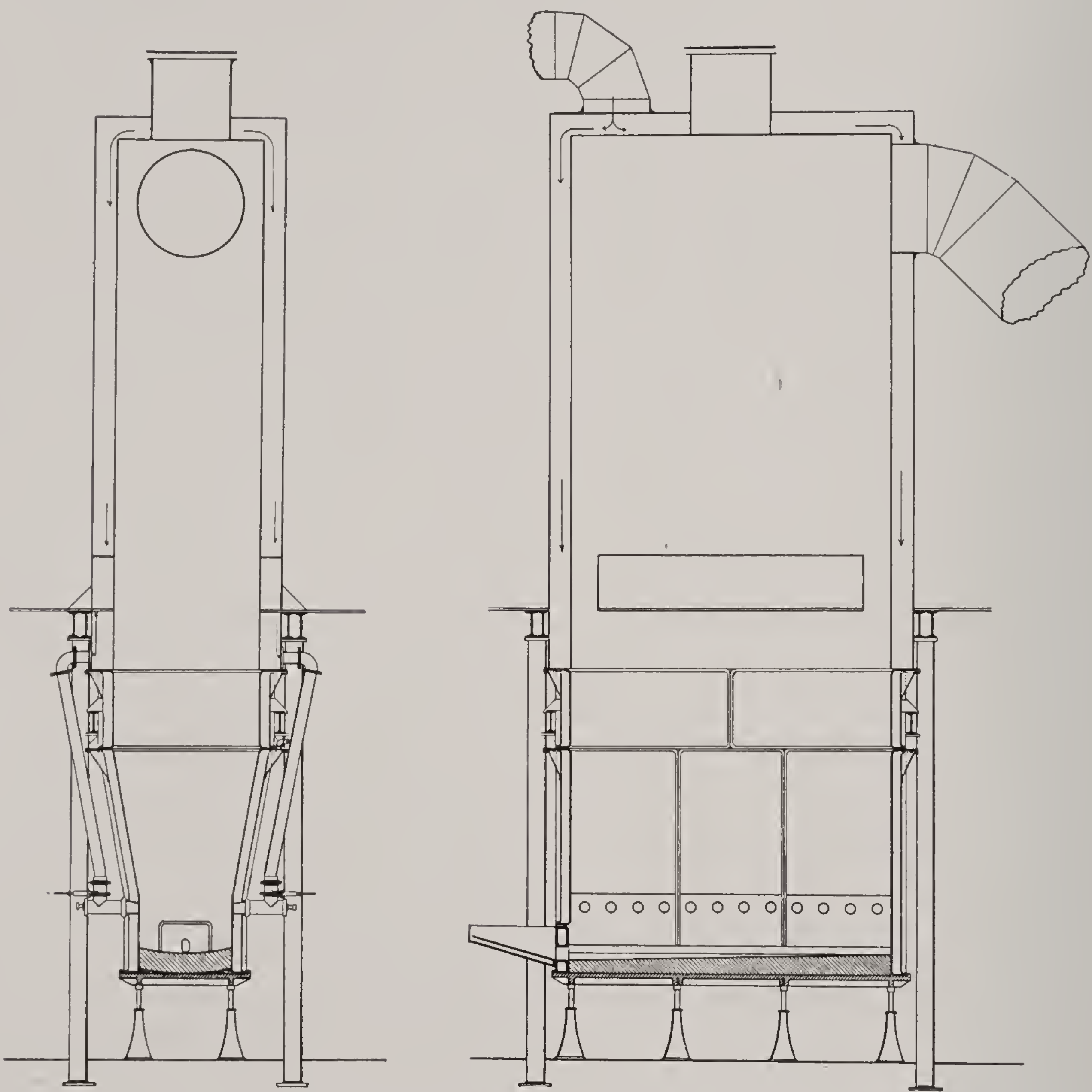


FIG. 52. COPPER MATTING FURNACE WITH AIR JACKETED HOOD.

matically, that is to say, should too much heat rise to the top of the charge, the air is heated to a higher temperature and consequently tends to bring the combustion down to the tuyeres where it belongs. Moreover, in using such a large hood, the velocity of the gases is reduced therein and a great percentage of the fine material drops down into the charge.

Copper Matting Furnace.

The outline cut below is of a 36 x 48 inch copper matting furnace, recommended as greatly superior to a circular furnace for small capacities.

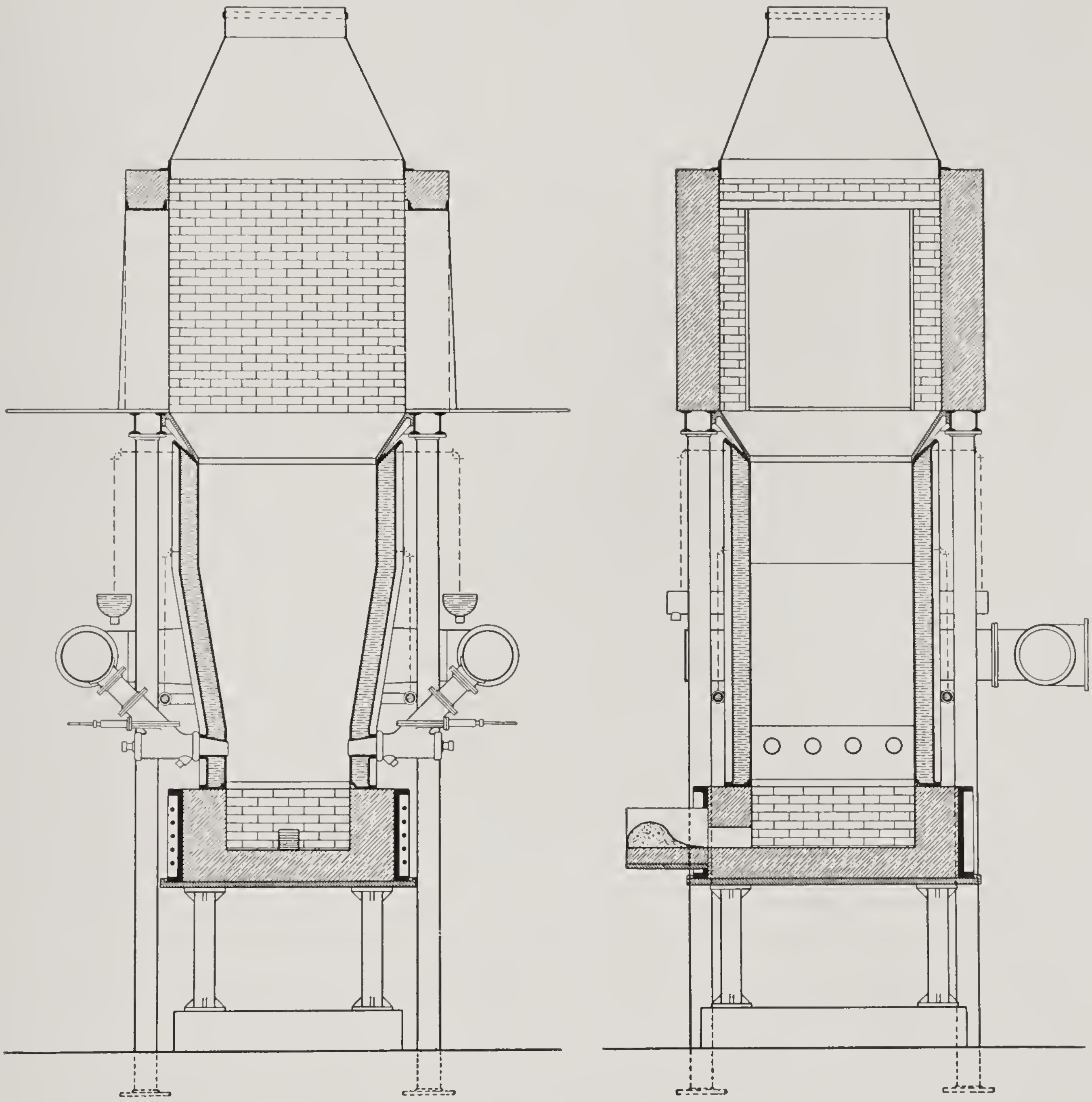


FIG. 53. SMALL RECTANGULAR COPPER MATTING FURNACE.

There is a single water jacket on each side and end, 96 inches in height, 84 inches in height above the tuyeres, and the design is on the same lines as the larger rectangular furnaces. In such a small unit, the water jackets, if carried down to the base plate, increase the tendency of the matte and slag to chill in the hearth. For this reason the hearth is constructed of refractory brick in the manner shown.

Copper Blast Furnace.

This blast furnace is so designed as to facilitate cleaning out and thereby reduce the time lost from freeze-ups, which are more liable to occur in operating small furnaces than large ones. The jackets are supported from the mantel frame by chains, so that they can be swung out without the rigging necessary to take them out bodily. In the furnace shown, the jackets are in narrow sections

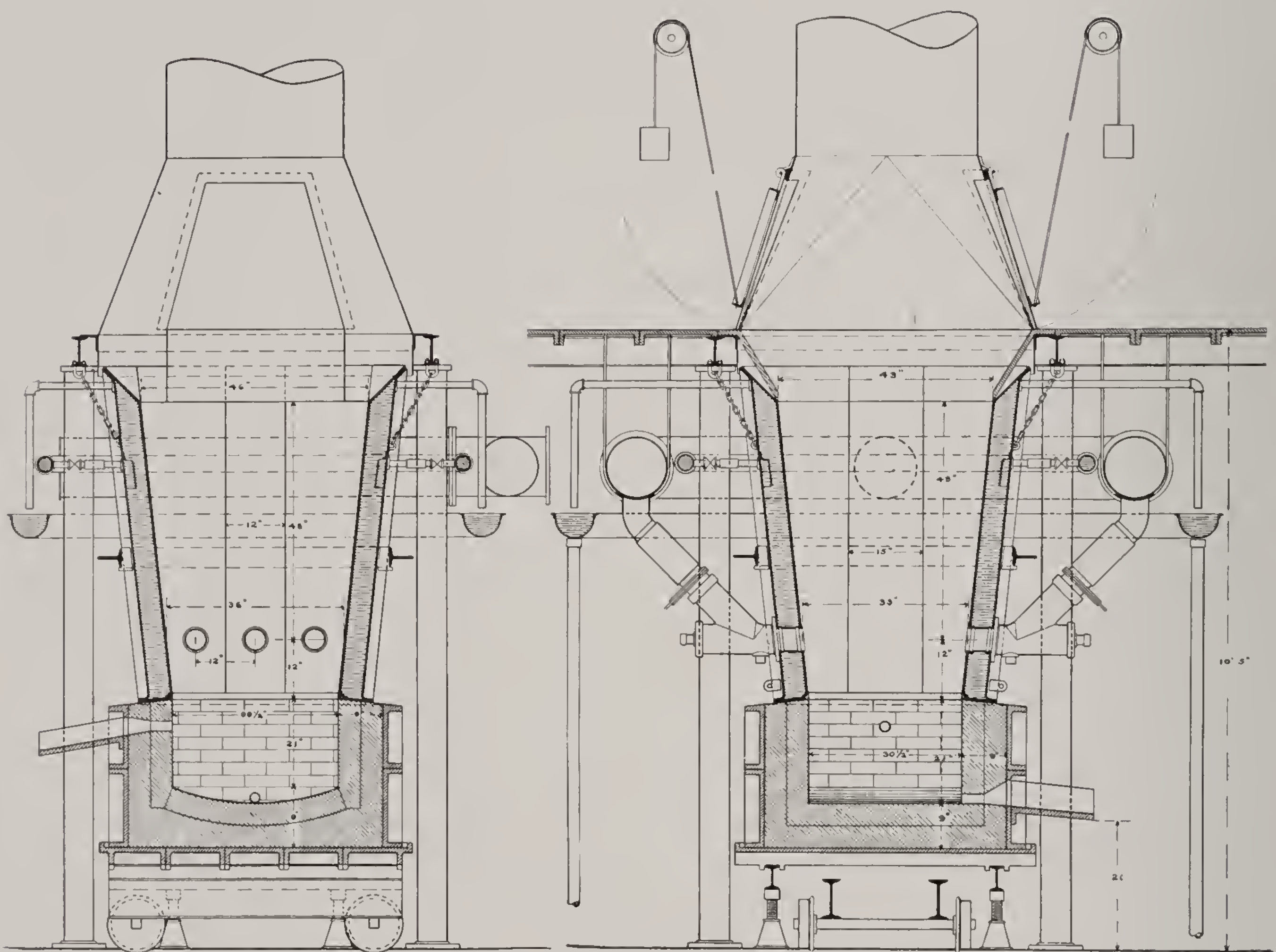


FIG. 54. SMALL RECTANGULAR COPPER FURNACE.

adapted to mule-back transportation, but ordinarily the side and end jackets would be made in one piece.

The removable crucible will appeal to those who have had experience in operating small furnaces. It is held in position against the lower edge of the jackets by jack screws, and for removal is lowered upon a truck. Two crucibles are supplied, which enables one to be kept in reserve, and by this means the time of cleaning out is reduced to a fraction of that customarily required. These features, and the further superiority of the rectangular form, should in most cases outweigh any considerations of less first cost of a round furnace.

Copper Matting Furnace.

The furnace here shown is designed along standard lines and has two tiers of steel jackets, the lower side jackets being in three sections and the upper side jackets in one piece. The upper end jackets are

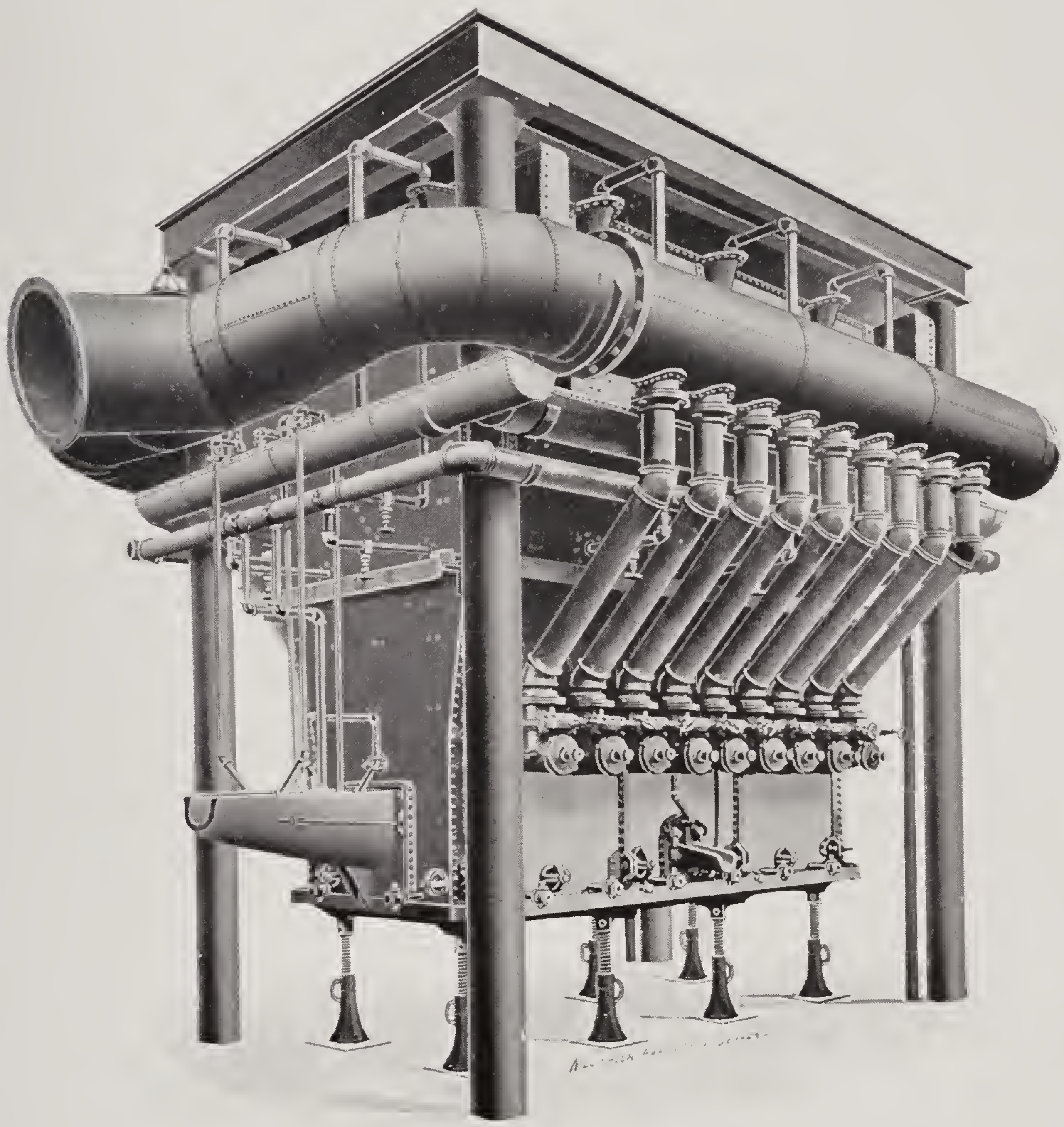


FIG. 55. 42″ x 120″ COPPER MATTING FURNACE.

extended sidewise and carried directly by brackets cast on the corner columns, these jackets in turn carrying the upper side jackets. The blow pipes are of standard pipe and the valves are built into the tuyeres.

Copper Matting Furnace.

This illustration is reproduced from a photograph of a recently built furnace with 45 degree inlet angle tuyeres, blow pipes of standard pipe and the Gross patent trap spout.

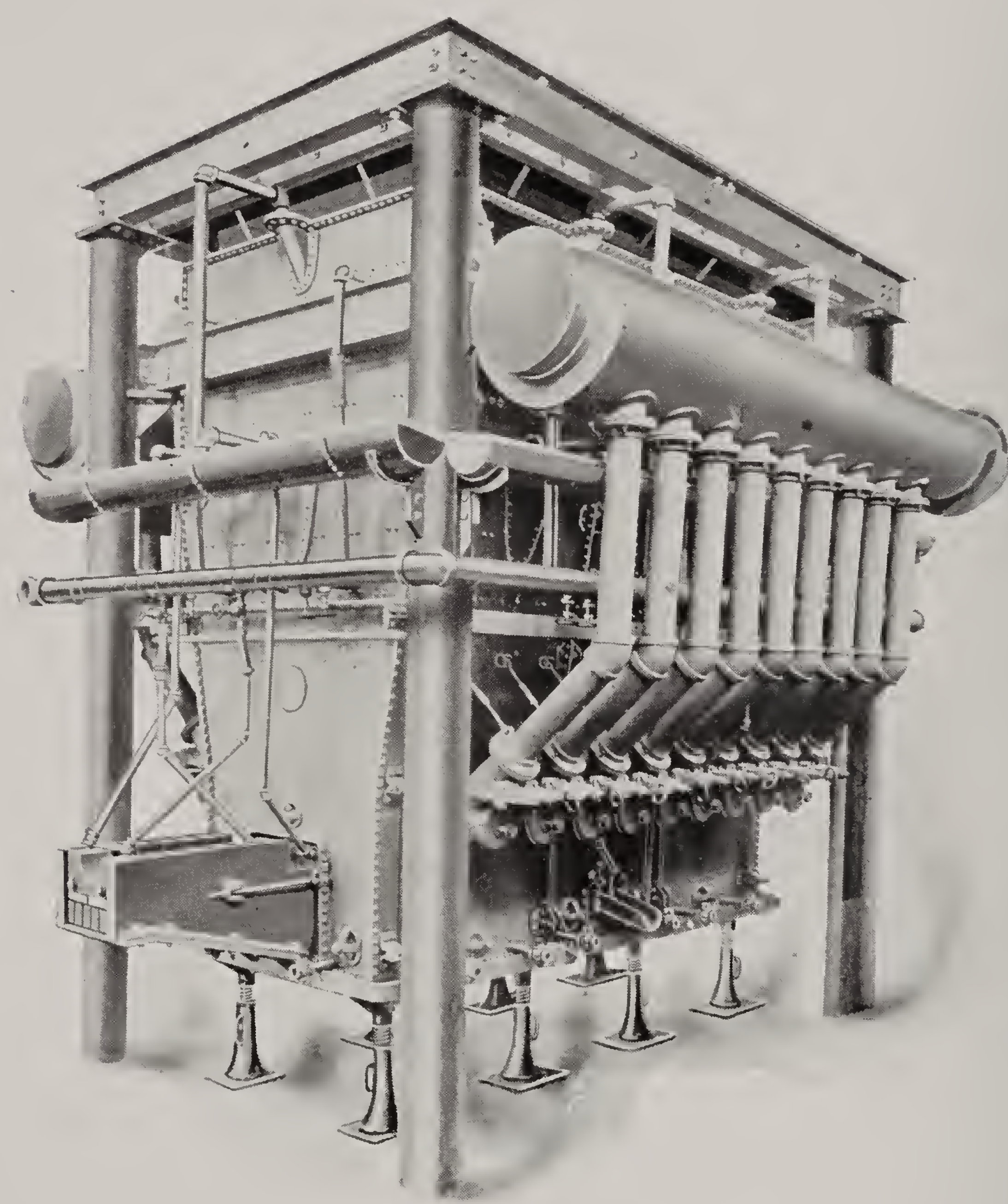


FIG. 56. 42″ x 120″ COPPER MATTING FURNACE.

It has two tiers of steel plate water jackets, the upper supported independently of any other part of the furnace by steel I-beam frame resting on brackets cast integral with the corner columns. The cast iron beveled feed plates show above the tops of the upper jackets. These do away with brick-work below the feed floor level.

Copper Matting Furnace.

The engraving on this page shows a copper matting blast furnace with two tiers of plate steel water jackets, the interior contour being as shown on page 74.

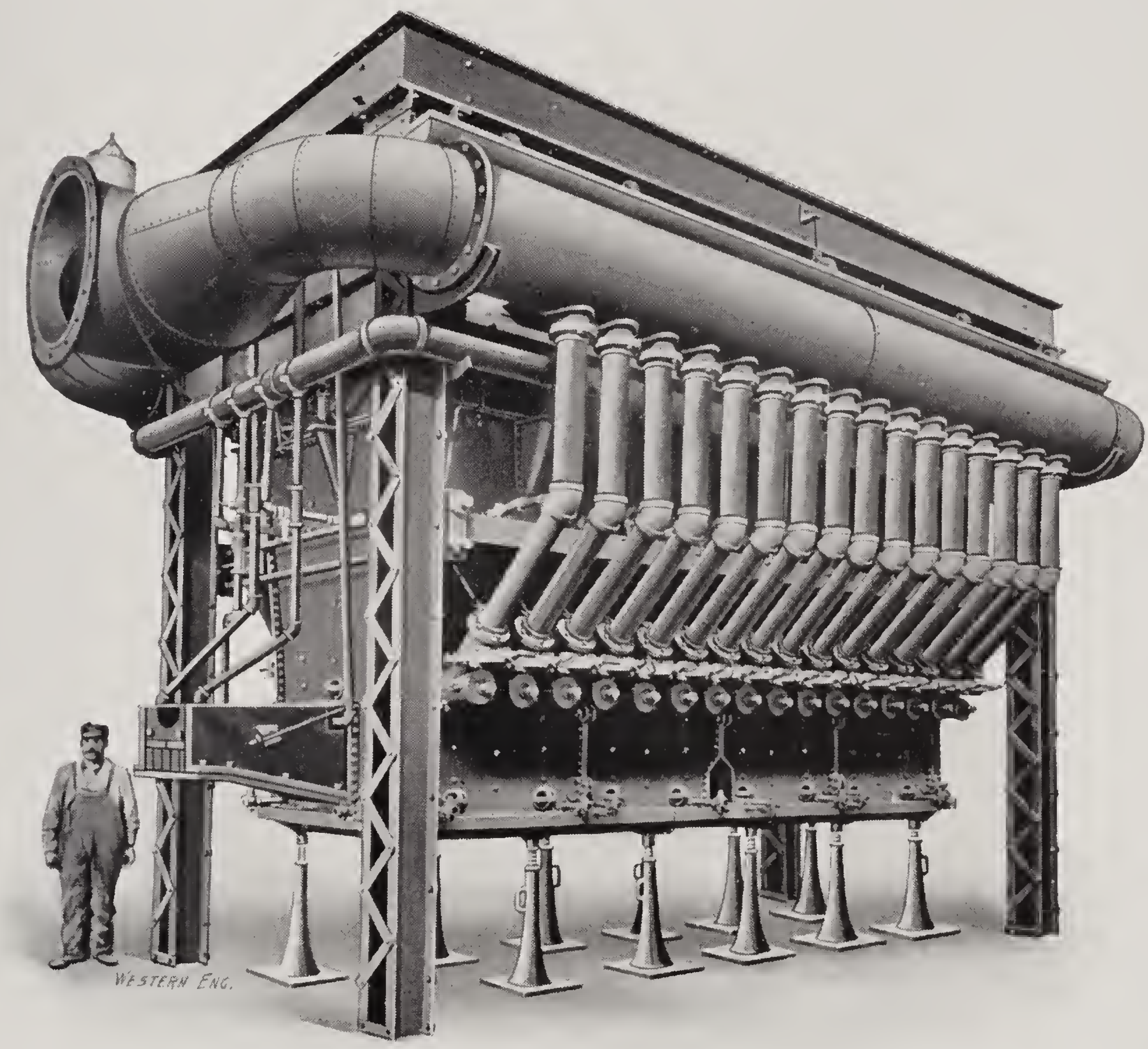


FIG. 57. 44″ x 200″ COPPER MATTING FURNACE.

This furnace embodies many desirable features and is a good example of a modern copper matting furnace of the highest type. As in our other furnaces, the upper tier of jackets is carried independently of the lower and cast iron beveled feed plates fill the space between the tops of the upper jackets and the feed floor, eliminating brick-work at that point.

Copper Matting Furnace.

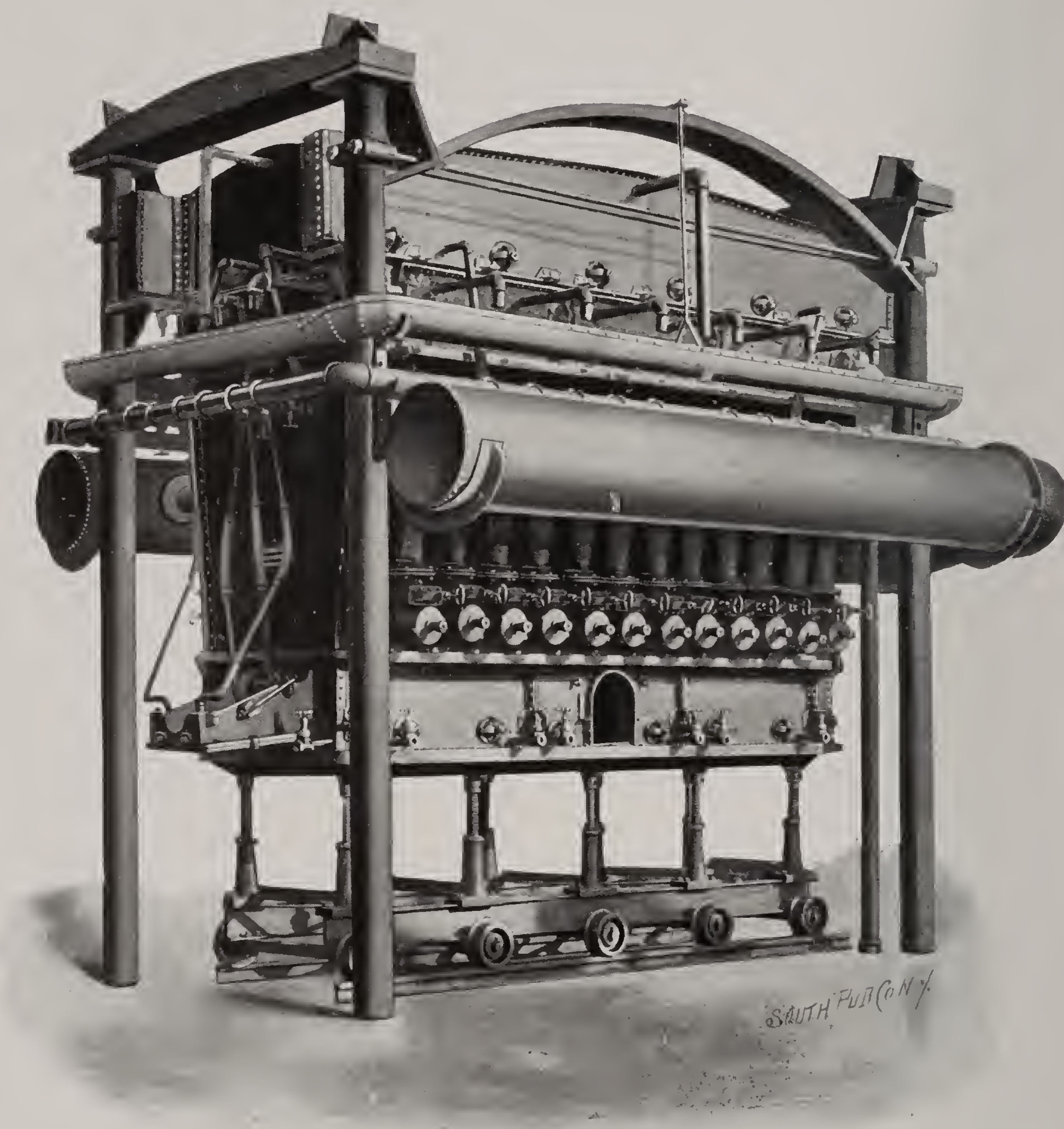


FIG. 58. 38″ x 144″ COPPER MATTING FURNACE.

This furnace differs from our standard construction in some respects, among which it may be mentioned that the bottom plate is carried on a truck. The water jacketed girder and arch-bar mantel system is here shown, the lower jackets being carried by hangers from the water jacketed girders when the bottom plate is removed.

Copper Matting Furnace.

This blast furnace is water jacketed from the bottom plate practically to the feed floor, the jackets being in two tiers, the lower side jackets in sections 26 inches wide and the upper side jackets in

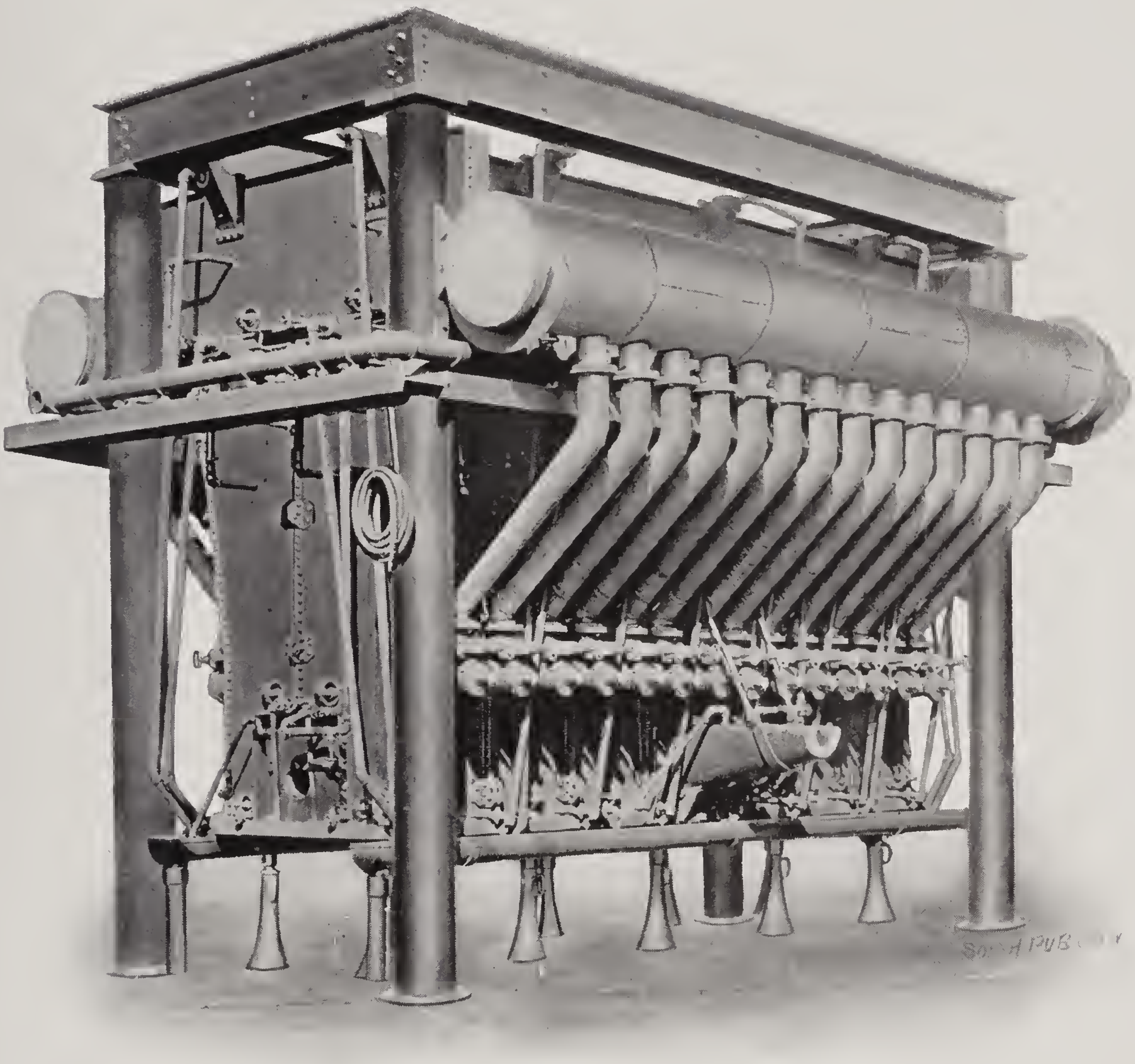


FIG. 59. 38″ x 180″ COPPER MATTING FURNACE.

two sections on each side of the furnace. The tuyeres have our built-in valves, giving easy control of the blast at each individual tuyere. On this furnace is shown a copper water jacketed spout in the center of the side, where it is sometimes placed in furnaces of considerable length.

Hot Blast Copper Matting Furnace.

This furnace is similar to the one illustrated on page 81 with respect to the arrangement of the jackets, but differs in the arrangement of the bustle pipe, waste water gutter, etc. The bustle pipe is

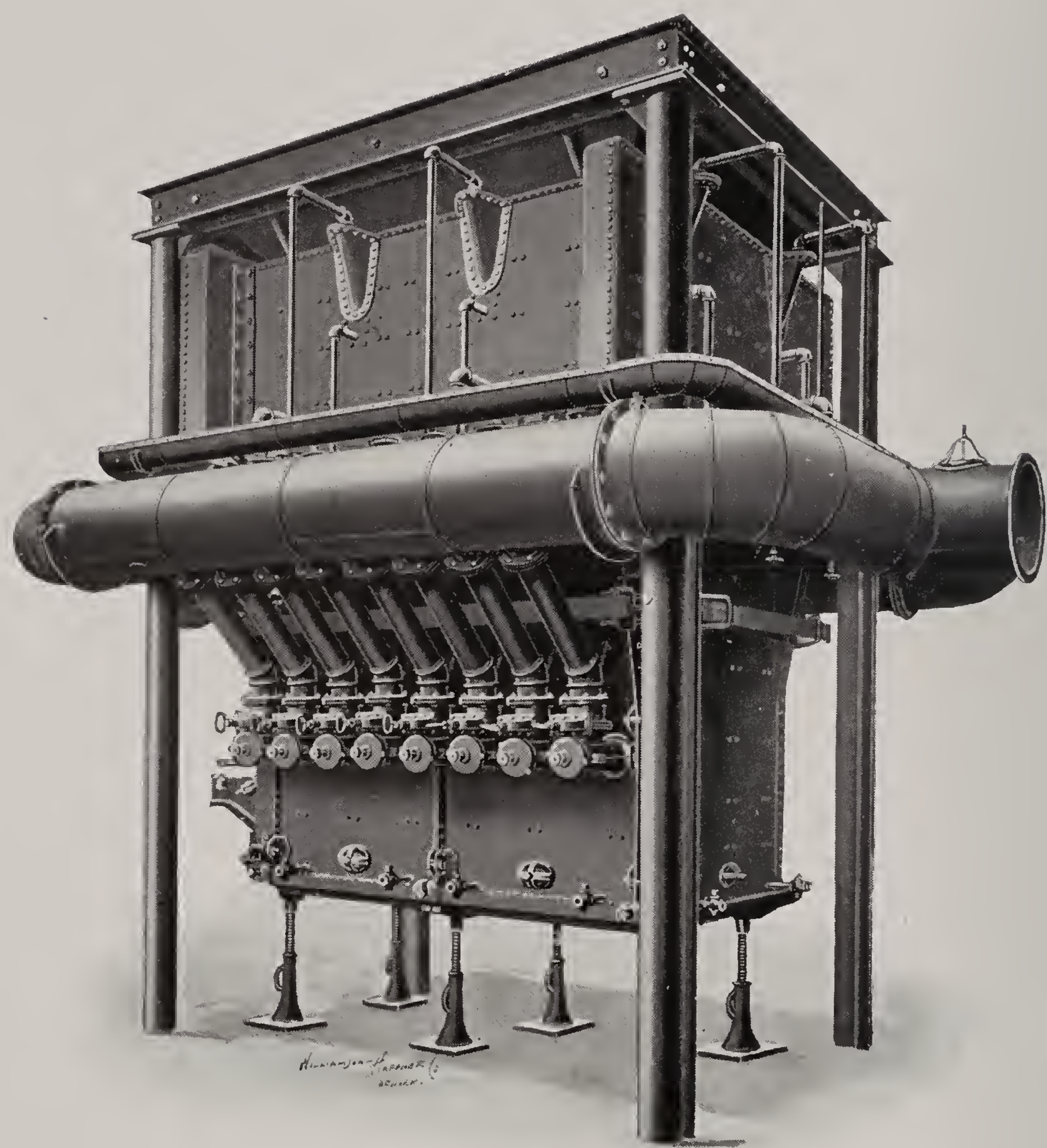


FIG. 60. 40″ x 96″ COPPER MATTING FURNACE FOR HOT BLAST.

lined with vitrified asbestos cell lining to reduce the loss of heat from radiation, and extends entirely around the furnace, with opening and gate at one end for hot blast and at the other end for cold blast, so that the stove can be cut out and the furnace operated on cold blast in an emergency. The beveled frame of cast iron plates is shown just above the tops of the jackets.

Hot Blast Copper Matting Furnace.

This engraving is of a recent copper matting furnace designed for semi-pyritic smelting with a highly heated air blast. The interior contour is as shown in the sectional drawing reproduced on page 75.

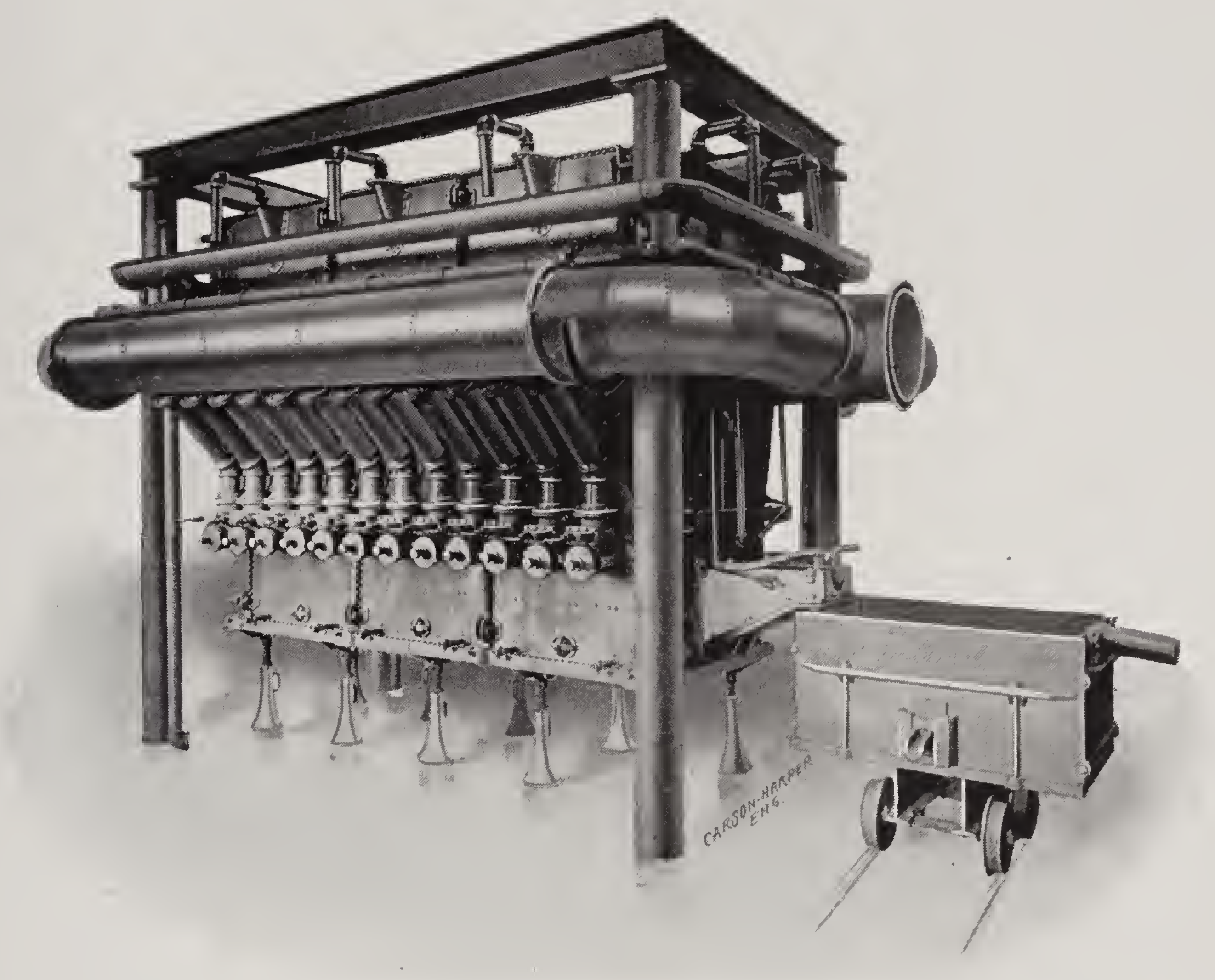


FIG. 61. 40″ x 144″ COPPER MATTING FURNACE FOR HOT BLAST.

The tuyeres are of cast iron with our individual, built-in tuyere valves and the blow pipes are covered with asbestos pipe covering. The bustle pipe is lined with the vitrified cellular asbestos which we have found so satisfactory for minimizing loss of heat. This furnace has the frame of cast iron beveled feed plates between the tops of the jackets and the feed floor, although it was not in position when the photograph was taken.

Hot Blast Copper Matting Furnace.

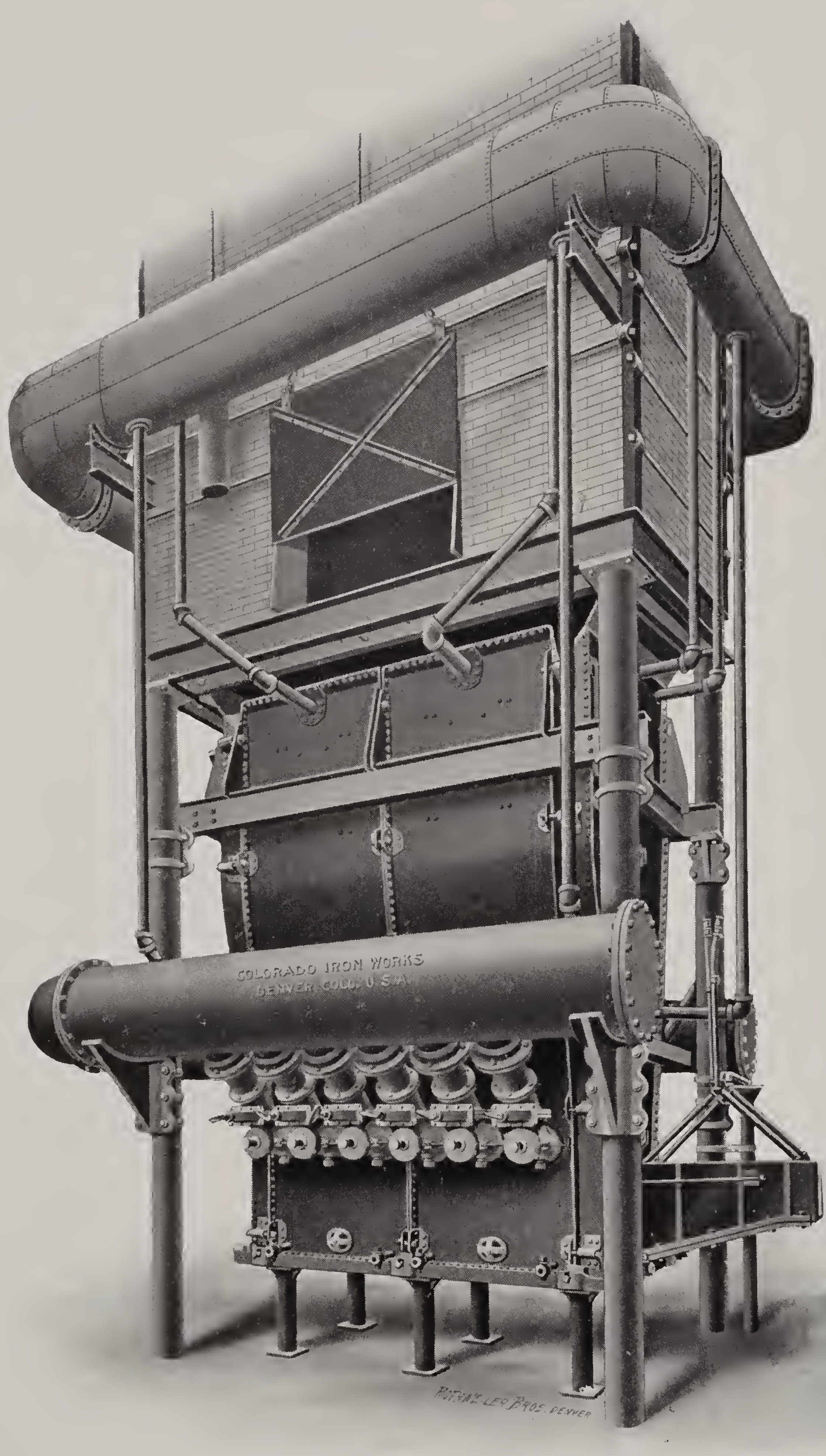


FIG. 62. 36″ x 84″ HOT BLAST COPPER MATTING FURNACE.

Hot Blast Copper Matting Furnaces.

The furnace shown as Fig. 62 has a single tier of jackets extending from the bottom plate to the frame of cast iron beveled feed plates at the feed floor level. The bustle pipe is of cast iron, lined with vitrified cellular asbestos and is placed close to the tuyeres to prevent undue loss of heat. This furnace is equipped with the Nesmith patent jacket water vaporizer by means of which the consumption of jacket water is reduced to a fraction of that ordinarily required. Since this furnace was built the purchaser duplicated the order.

In Fig. 63 we show a recently built and very efficient hot blast copper matting furnace. The tuyere valves are located immediately under the bustle pipe with the upper ends of the blow pipes connected to the valves through stuffing boxes, thereby permitting the removal of any tuyere and blow pipe, while the furnace is in operation, by first closing its valve. The bustle pipe is lined with vitrified cellular asbestos and the blow pipes are covered with asbestos pipe covering.

The lower water jackets are braced by vertical steel I-beams at the joints to avoid the necessity of removing the entire binder as in the usual construction. The upper tier of jackets is supported by a steel I-beam girder frame carried upon brackets bolted to the four corner columns.

Hinged drop doors are fitted to the furnace bottom plate, the latter being rigidly supported by twelve short cast iron columns.

The furnace is arranged for automatic charging from cars running along each side on the feed floor, the doors on the sides being hinged. The balanced door at each end of the superstructure is for the purpose of giving access to the interior of the furnace.

The brick superstructure is as shown in Fig. 79 and is of approved design. Its large volume of free space directly above the furnace enables much of the coarser flue dust to fall back upon the top of the charge instead of being carried over into the dust chamber. Connection with the downtake leading to the dust chamber is through the circular opening shown at the top.

Hot Blast Copper Matting Furnace.

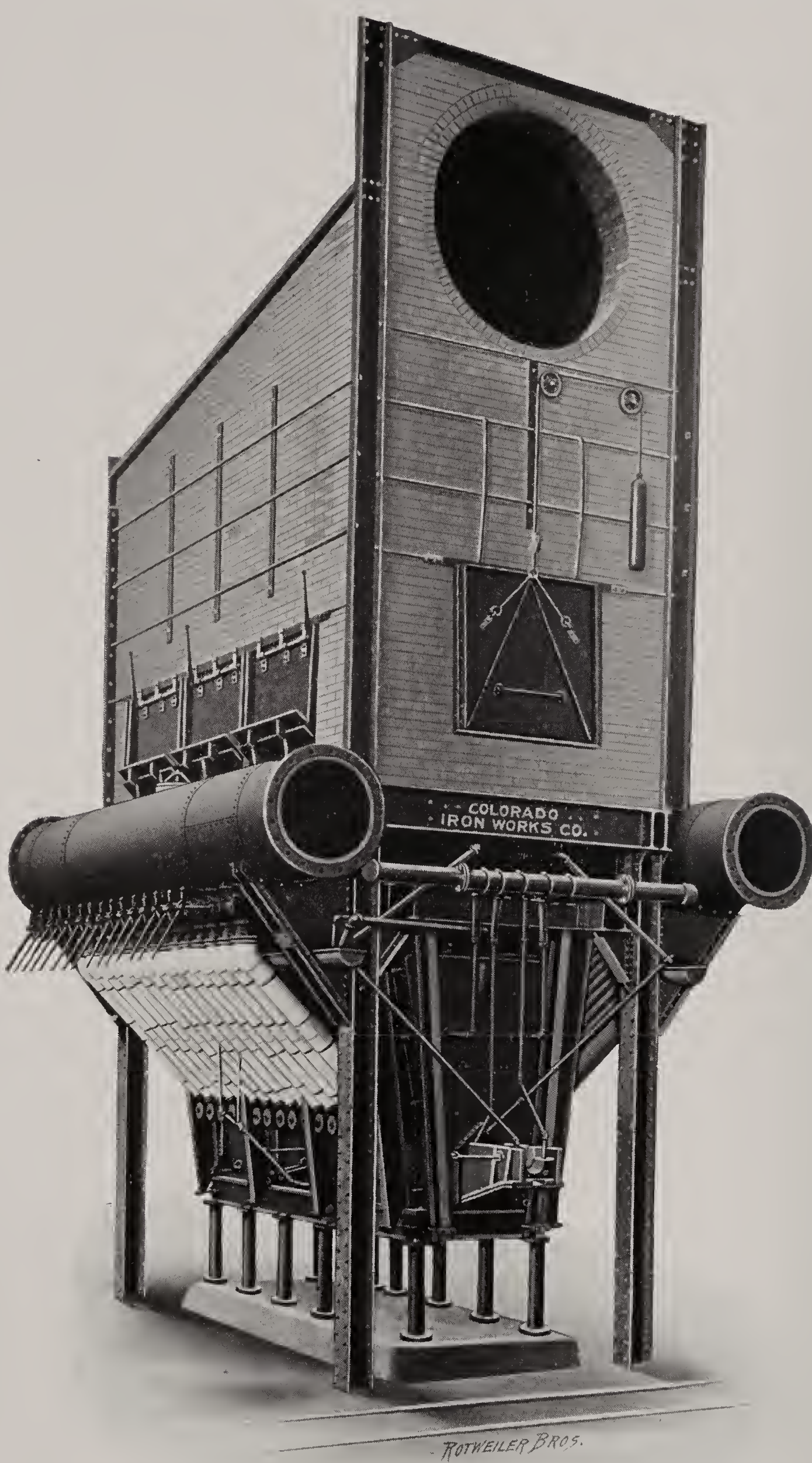


FIG. 63. 38″ x 180″ HOT BLAST COPPER MATTING FURNACE.

Hot Blast Copper Matting Furnace.

This illustration is from a photograph of a large hot blast copper matting furnace provided with the Nesmith patent jacket water vaporizer and having the lower jackets of steel plate and the upper jackets cast iron, a combination which we have made to some extent.

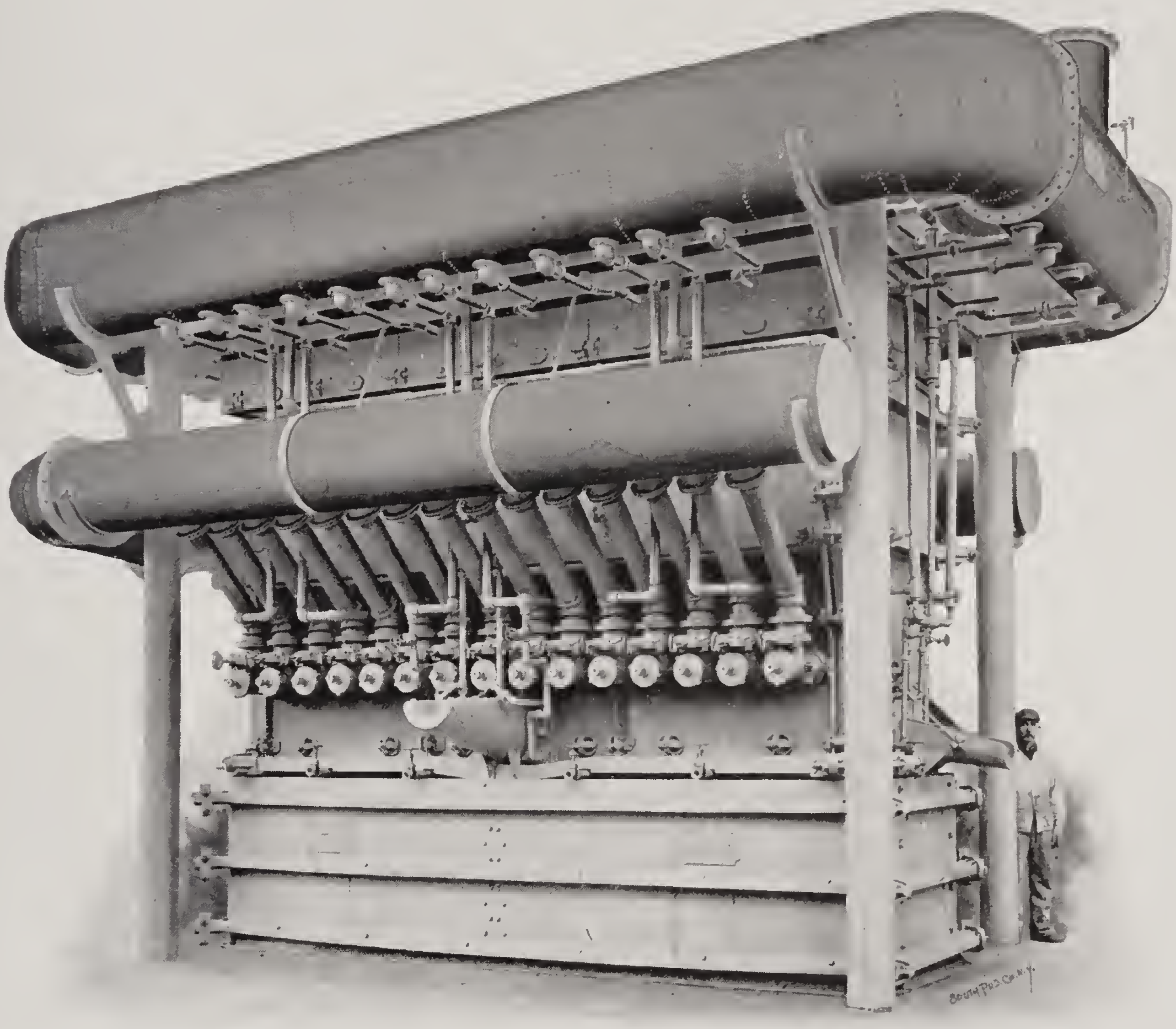


FIG. 64. 36″ x 180″ HOT BLAST COPPER MATTING FURNACE.

Our usual practice of lining the blast main leading from the stove and the bustle pipe with vitrified cellular asbestos was followed, and the interior contour of the furnace was correct, but some departures from our approved designs were made at the solicitation of the metallurgist who was to operate the furnace, the most important of which was the omission of the bottom plate, the space below the jackets being bricked up solid, which we did not and do not recommend.

Hot Blast Copper Matting Furnace.

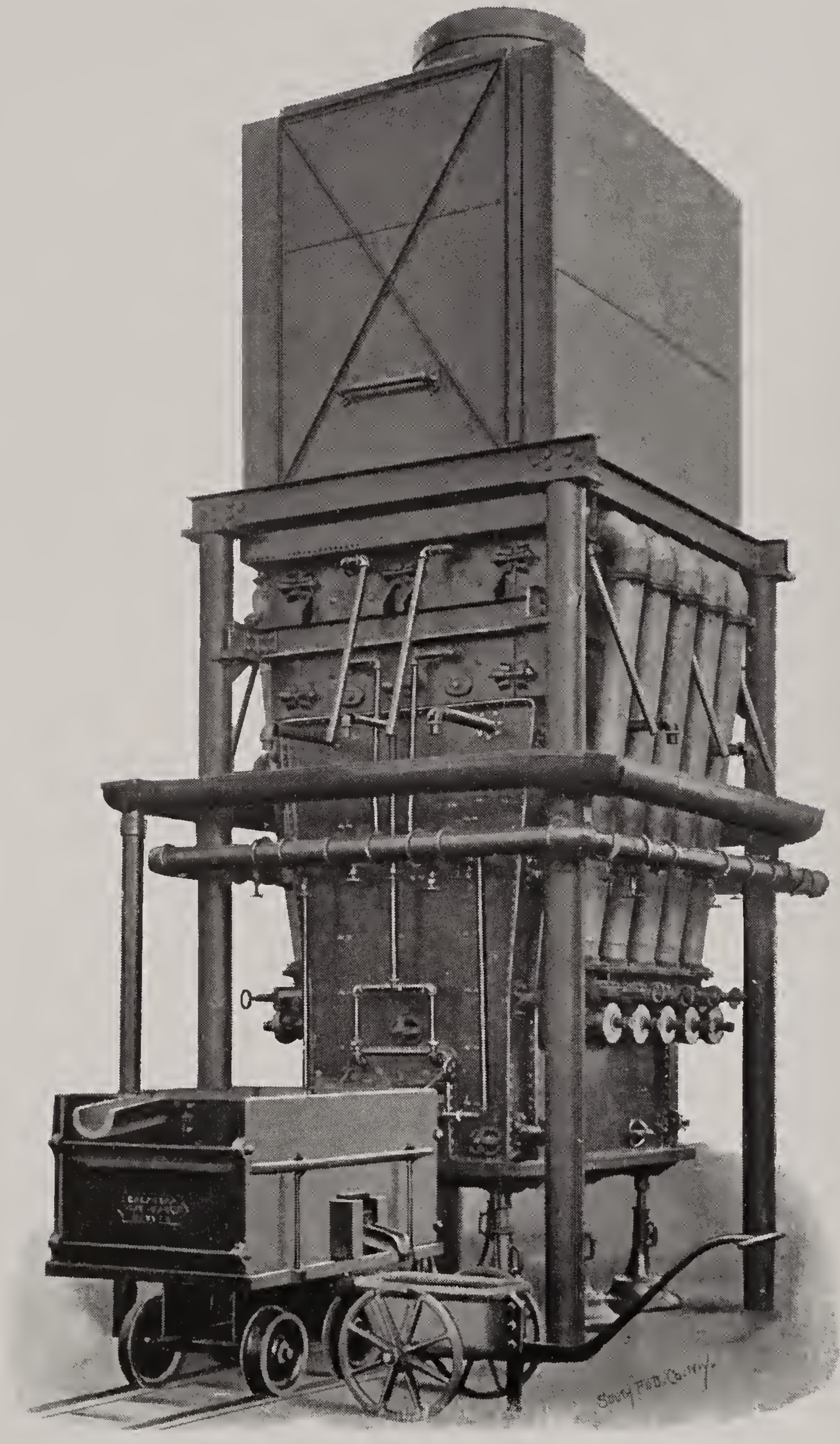


FIG. 65. 36″ x 60″ COPPER MATTING FURNACE.

In the above furnace the blast passes through an air jacketed hood similar to that shown on page 78 and is warmed by the heat in the escaping gases. Naturally, this is a less efficient method of heating the blast than our U-pipe stove, but there is nevertheless a distinct gain although the air is not sufficiently heated to bring the operation within the designation of hot blast smelting.

Copper Blast Furnace.

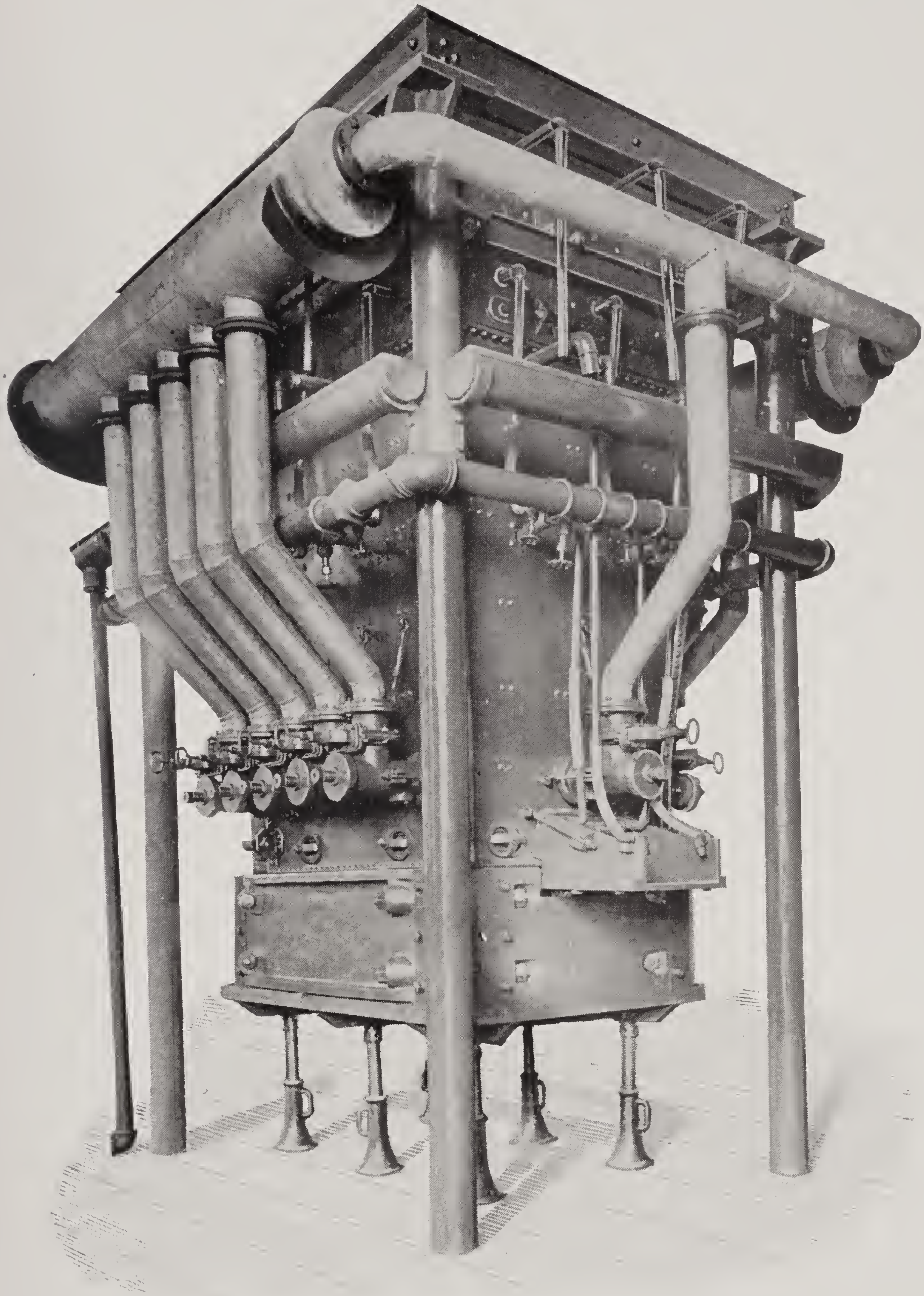


FIG. 66. 36″ x 60″ COPPER FURNACE FOR INSIDE SEPARATION.

This furnace is boshed on the ends as well as the sides and has a tuyere at each end. It was designed for smelting oxide ores to black copper and consequently has a crucible.

Copper Blast Furnace.

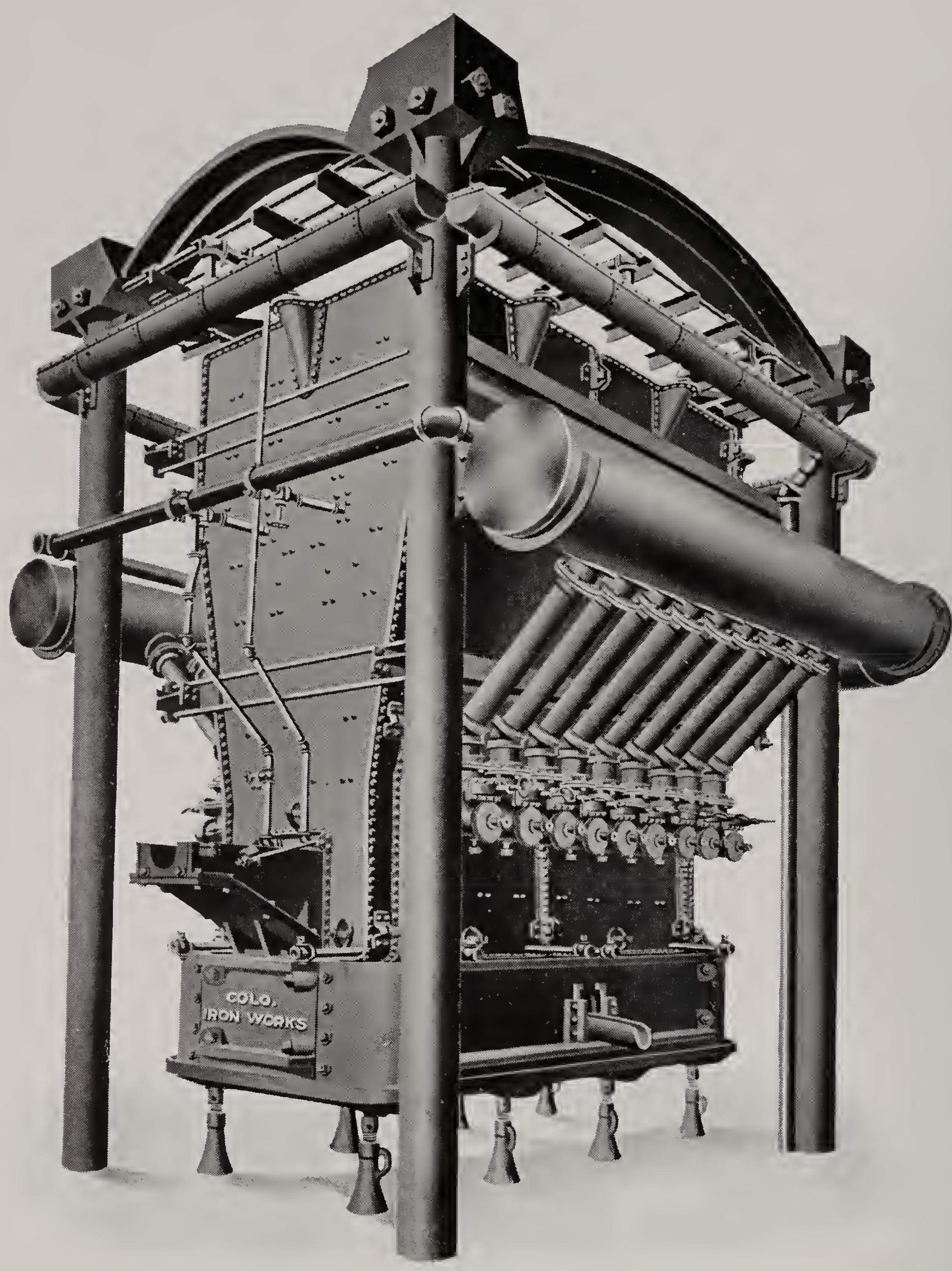


FIG. 67. 36″ x 108″ COPPER FURNACE FOR INSIDE SEPARATION.

In the above furnace the jackets are in a single tier with interior contour similar to our usual practice. It was designed for a brick shaft between the tops of the jackets and the feed floor to meet the desire of the purchaser.

Copper Blast Furnace.

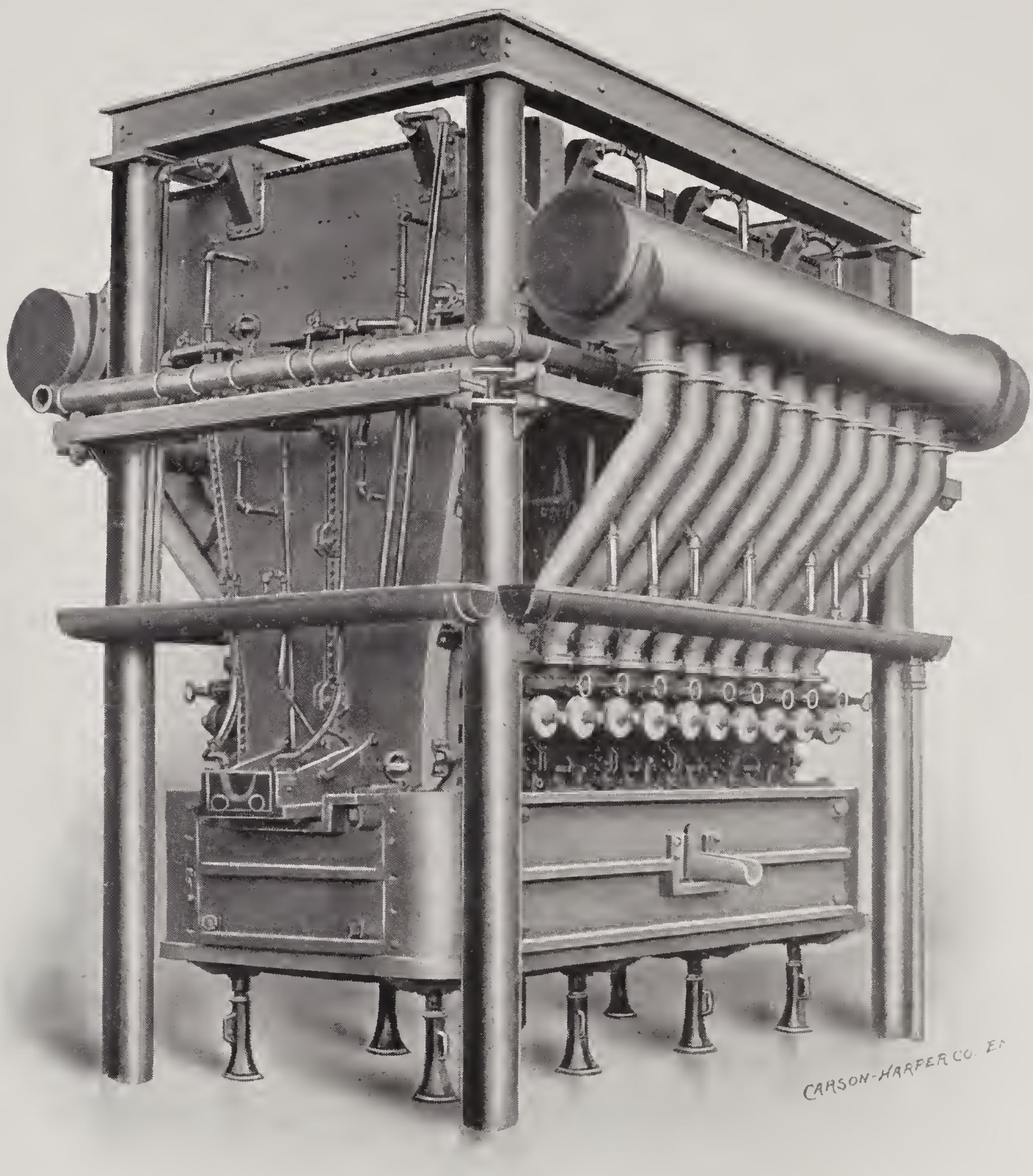


FIG. 68. 36″ x 120″ COPPER FURNACE FOR INSIDE SEPARATION.

The furnace shown above was designed along standard lines. It has a crucible for inside separation and is adapted to smelt carbonate ores to black copper or charges low in sulphur to a high grade matte, liable to chill if separated in an outside forehearth.

A furnace of this type is indicated for a property producing oxidized ore and expecting to reach sulphides upon development of the mine to greater depth.

Copper Matting Furnace.

This type of furnace we recommend in place of the usual round furnace, as the correct interior contour can be secured by jackets continuous throughout their entire height with the advantage of having but one point at which sediment can collect. This construction also permits easier access to the interior or renewal of one jacket section should it become damaged by any means. In designing furnaces on this general plan, the 36-inch is made hexagonal, 42-inch

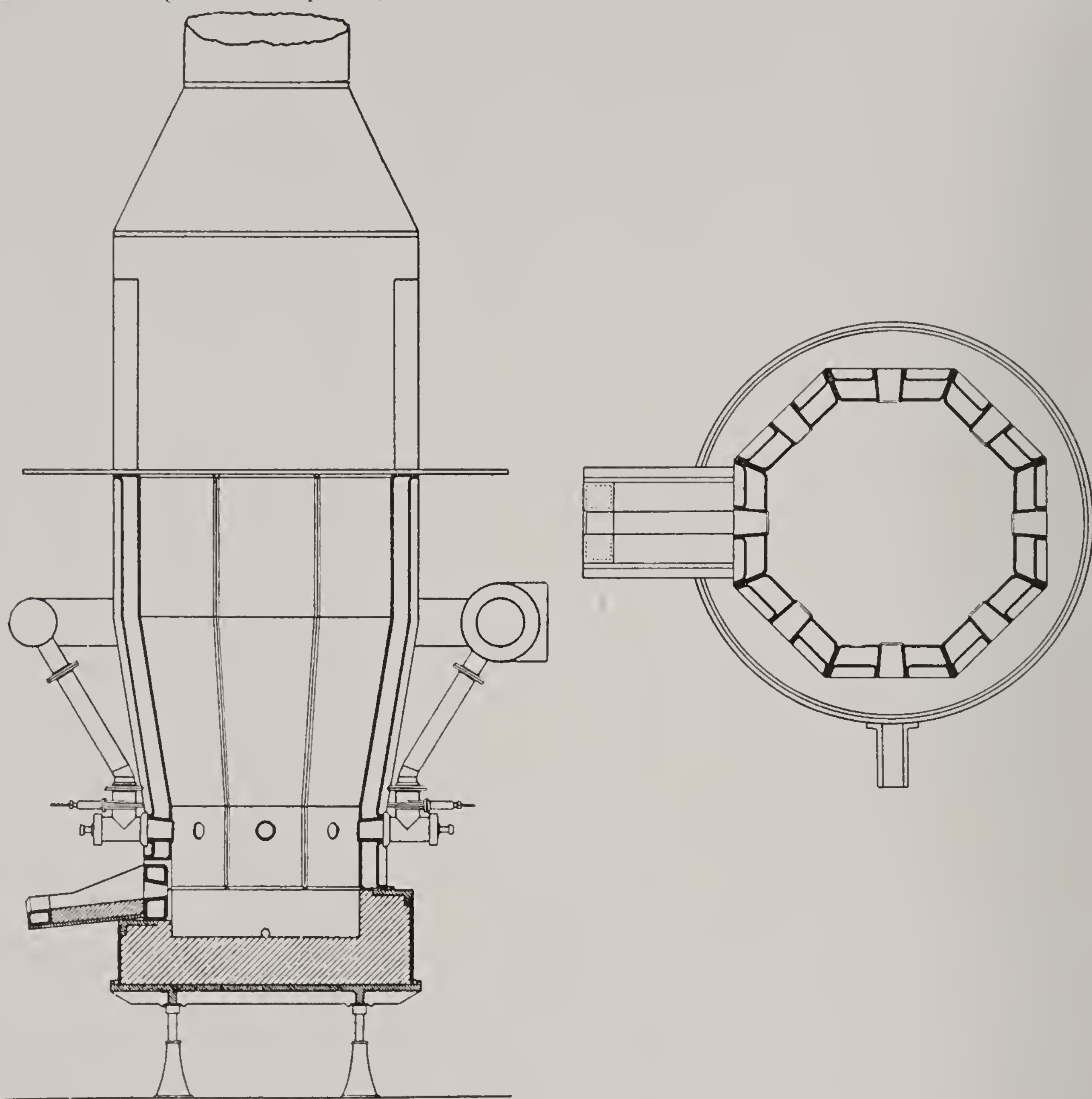


FIG. 69. POLYGONAL COPPER MATTING FURNACE.

heptagonal, and 48-inch octagonal, except in furnaces designed for mule-back transportation, when the division is made as small as necessary to keep within the permissible weight.

While the above furnace is particularly designed for smelting copper sulphide ores to matte, it will give equally as good results on oxidized or carbonate ores, as on sulphides; in the former case, separation being carried on in the crucible, while in the latter, the matte is separated on the outside of the furnace in some form of settler, and the furnace may, if desired, be run with a trapped blast and continuous flow of slag and matte.

Copper Blast Furnace.

This blast furnace is of the same general design as the one shown on page 96 but has a deeper crucible, adapting it to smelting oxidized ores to black copper. Molten copper loses its heat very rapidly and the brick lined crucible is necessary to prevent chilling. The slag is tapped from the upper spout and the copper from the lower.

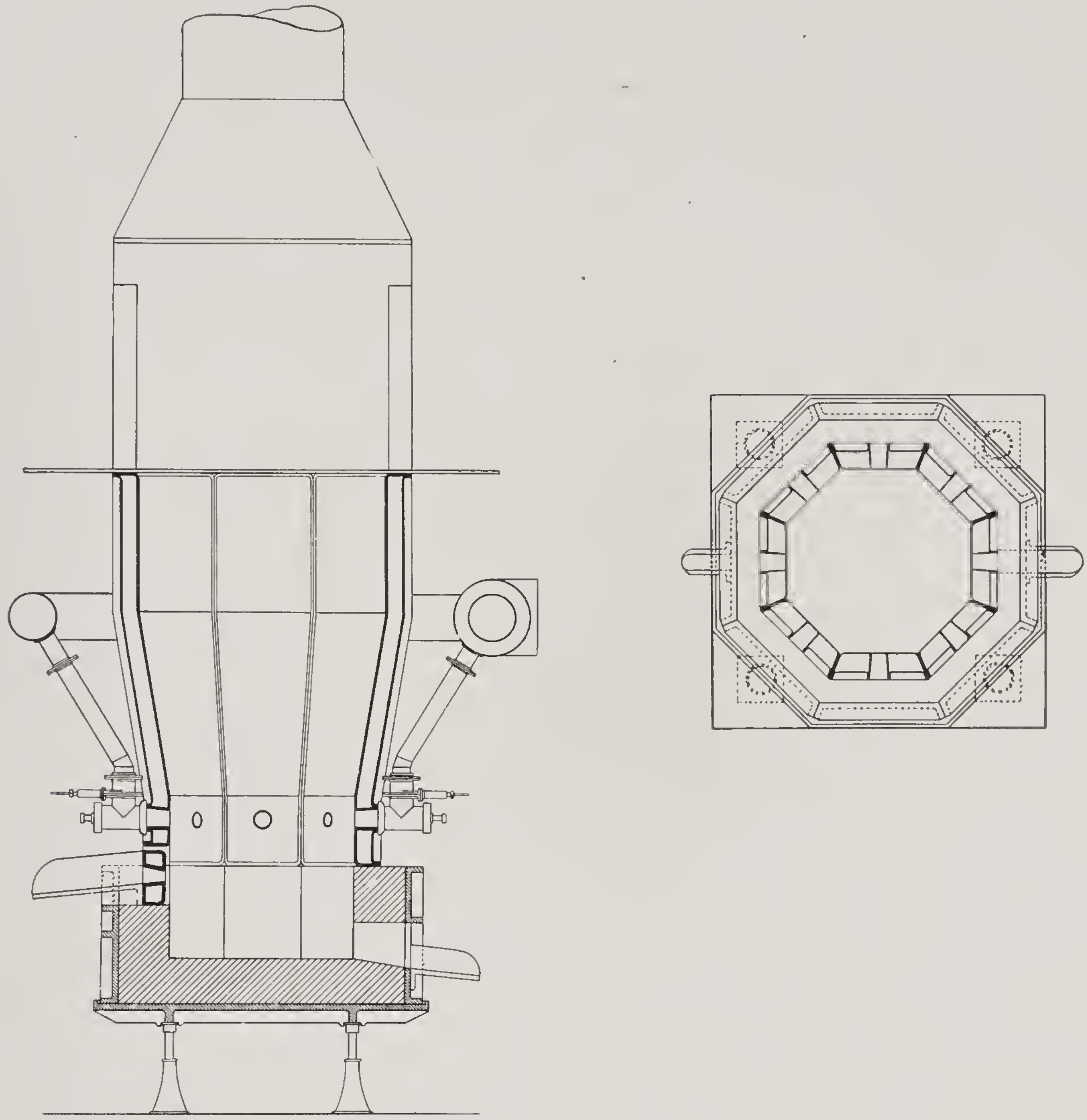


FIG. 70. POLYGONAL COPPER BLAST FURNACE.

A furnace of this kind is very desirable for a small property producing oxide, carbonate and other surface copper ores, as when sulphides are encountered as depth is gained the crucible can be bricked up solid and the ores smelted to a matte.

What is said as to sizes built, in connection with the furnace shown on page 96 applies here also. In the above furnace the crucible is made of heavy cast iron plates conforming in shape to the jacketed portion which can be readily taken apart if necessary.

Copper Matting Furnace.

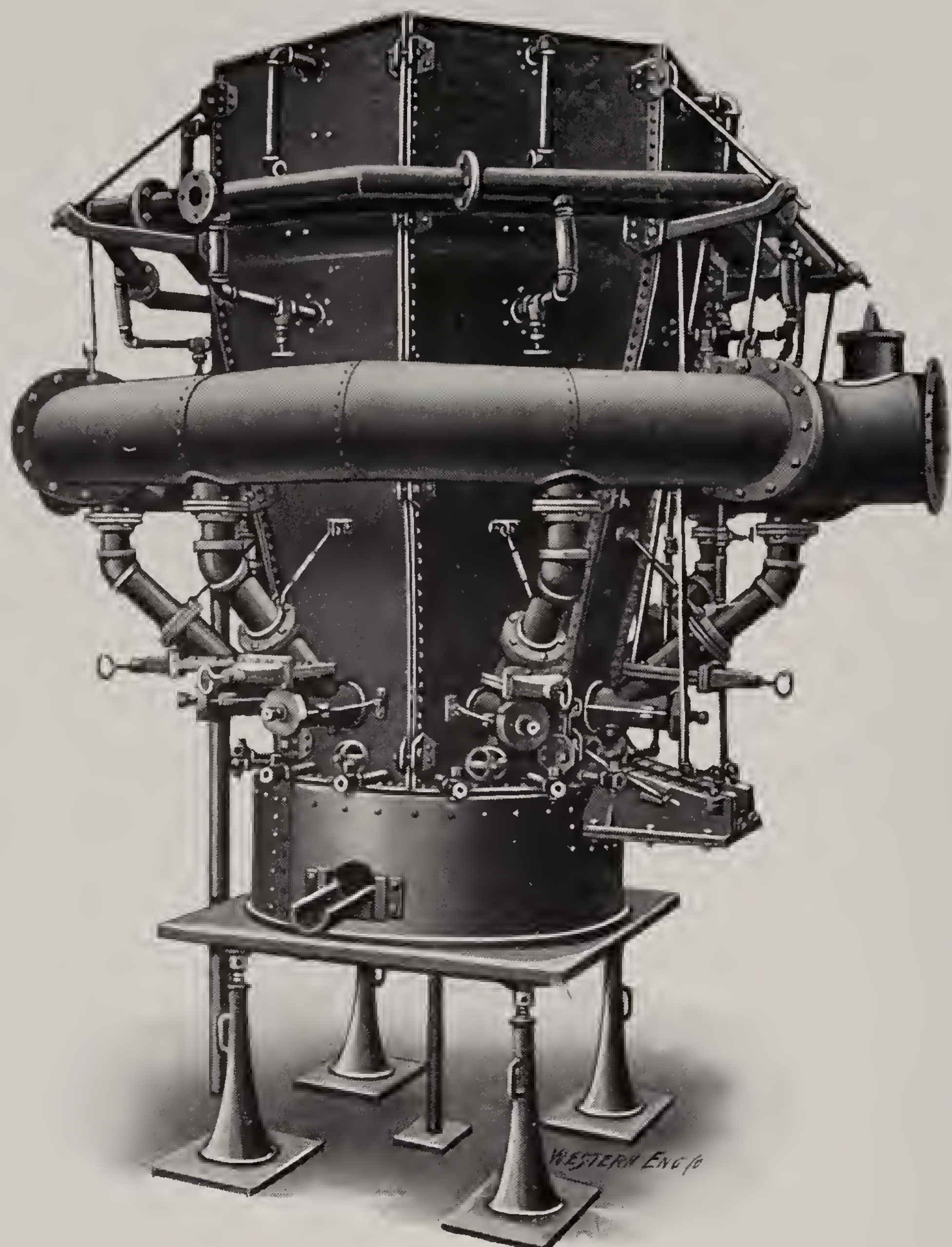


FIG. 71. 42″ HEPTAGONAL COPPER MATTING FURNACE.

The above illustration is reproduced from a photograph of a matting furnace 42 inches internal diameter at the tuyere level, built as shown in the horizontal and vertical sectional drawings on page 96, but with seven jackets and seven tuyeres instead of eight as in a 48-inch furnace.

In addition to the advantages due to having the jackets in vertical sections, we are enabled in furnaces of this type to make the jackets in our most approved manner, with no rivet heads exposed to the fire and all seams brought outward where they are exposed to view.

Furnaces of this type are emphatically recommended where the best obtainable is desired.

Copper Blast Furnace.

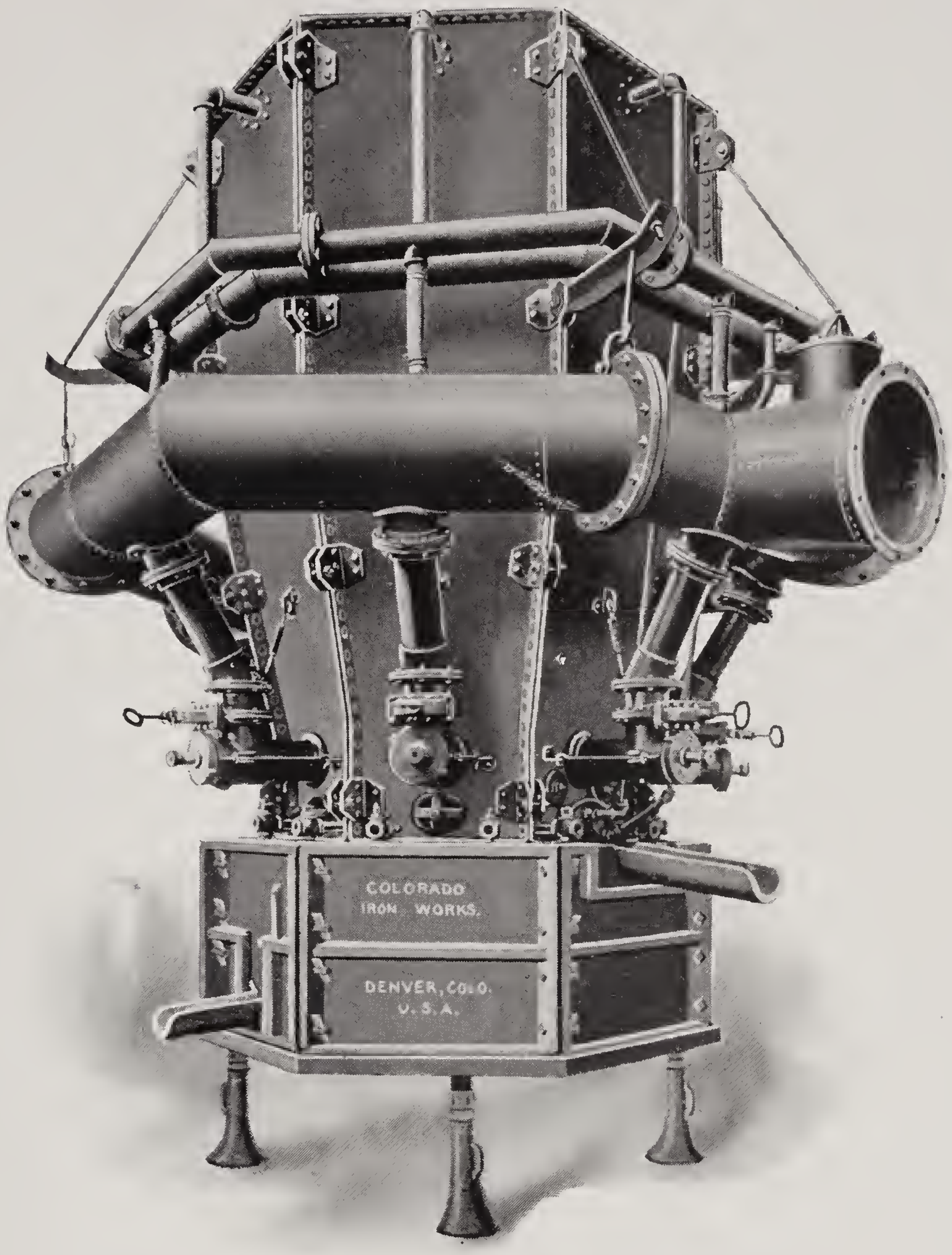


FIG. 72. 42″ HEPTAGONAL COPPER BLAST FURNACE.

This furnace was built for smelting oxidized copper ores to black copper and conforms to the drawings reproduced on page 97. It has seven jackets with one tuyere to each jacket and is provided with the deep crucible within a heptagonal curb of heavy, ribbed cast iron plates.

A furnace of this kind can always be easily changed to adapt it for copper matting with outside separation by bricking up the crucible. Although the jackets do not extend as far downward as in our rectangular matting furnaces, it is not desirable that they should do so, as in copper matte smelting in small furnaces it is necessary to protect the hearth from chilling while in large furnaces there is usually an excess of heat at this point which it is well to dispose of.

Copper Blast Furnace.

This furnace is constructed with steel plate water jackets along the lines of the drawing shown on page 96, but being designed for transportation on mule-back, with a further subdivision of the jackets.

The horizontal section at the tuyere level is that of a decagon, with a tuyere in every other jacket, that is, with ten jackets and five

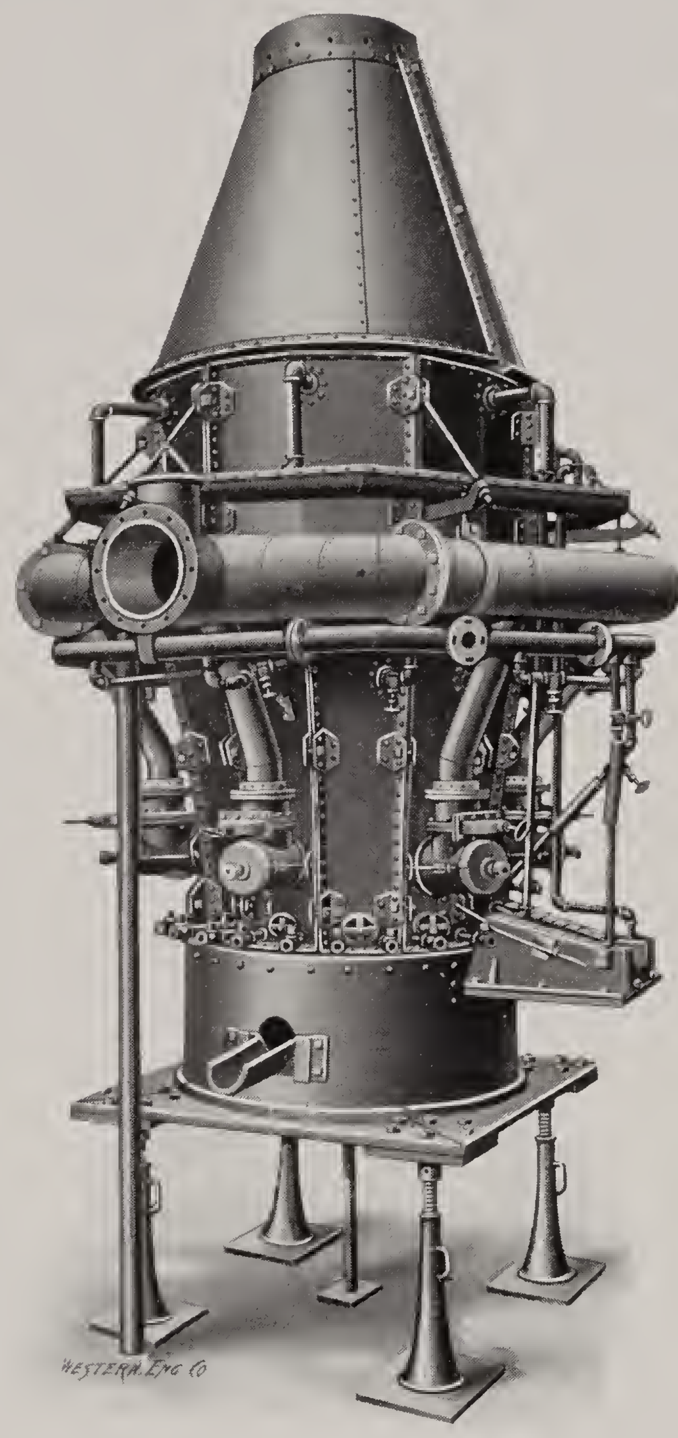


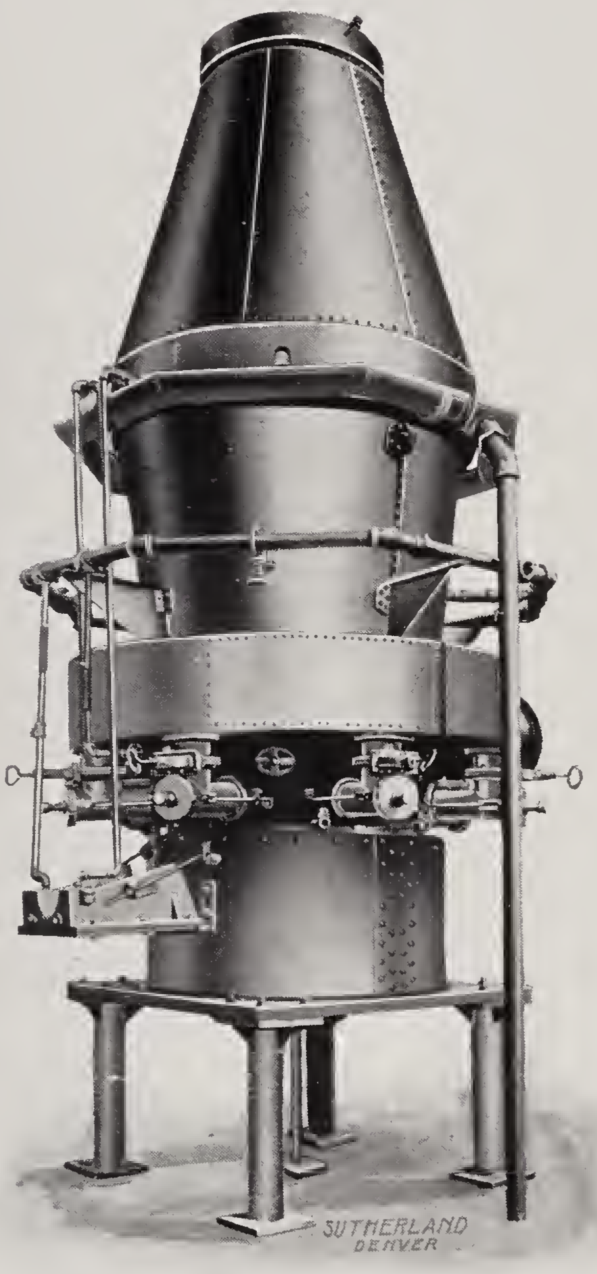
FIG. 73. 36″ SECTIONALIZED DECAGONAL COPPER FURNACE.

tuyeres. There is an upper tier of five jackets. No single piece of this furnace weighs over 325 pounds.

We also build 42-inch and 48-inch furnaces sectionalized in the same manner, which in metallurgical results are equal to those not sectionalized, and our large experience in this line enables us to meet problems of this kind in a most satisfactory manner.

Copper Blast Furnace.

The engraving and sectional view on this page show our circular copper furnace with plate steel water jacket constructed in vertical halves and with continuous bosh from bottom to top. The crucible in this case is built entirely independent of the jacket and where



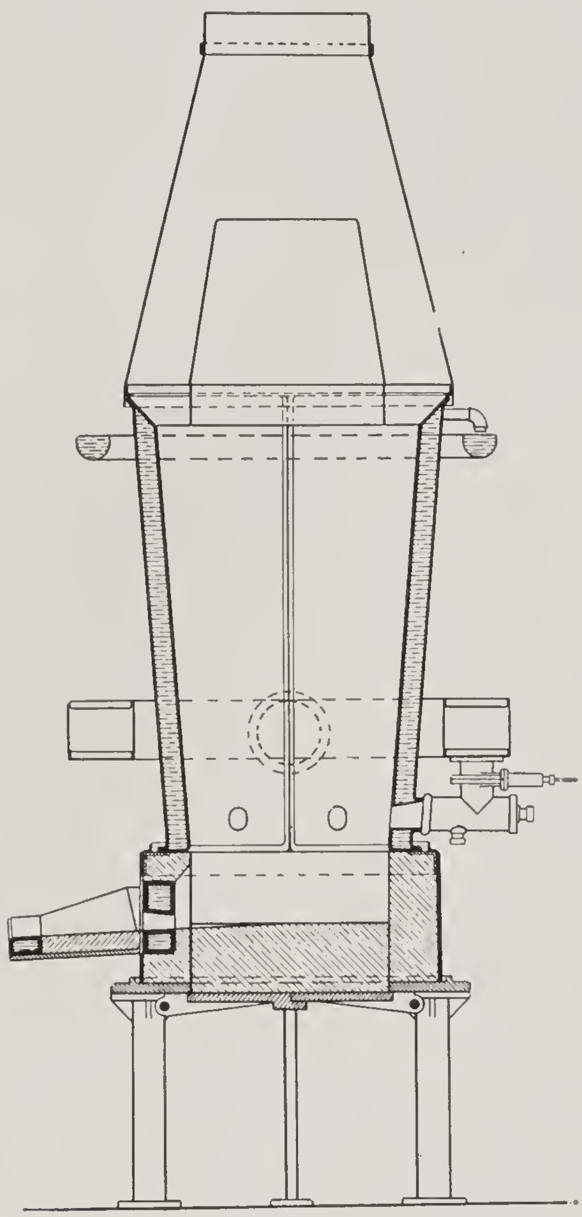


FIG. 74. 36″ ROUND COPPER BLAST FURNACE.

oxidized or carbonate ore is to be smelted, the crucible is made in two pieces securely bolted together. The circular wind box being also in halves, the whole may be very easily taken apart for cleaning out. Each tuyere is entirely independent of all others and has an air-tight gate in order to control the air blast.

Copper Blast Furnace.

This furnace was 42 inches in diameter at the tuyeres. The jacket is in three ring-like sections, and while this makes the securing of a proper interior contour a simple matter, the three points at which sediment can collect is a great disadvantage and we would not recommend such a furnace where the water was not of the best.

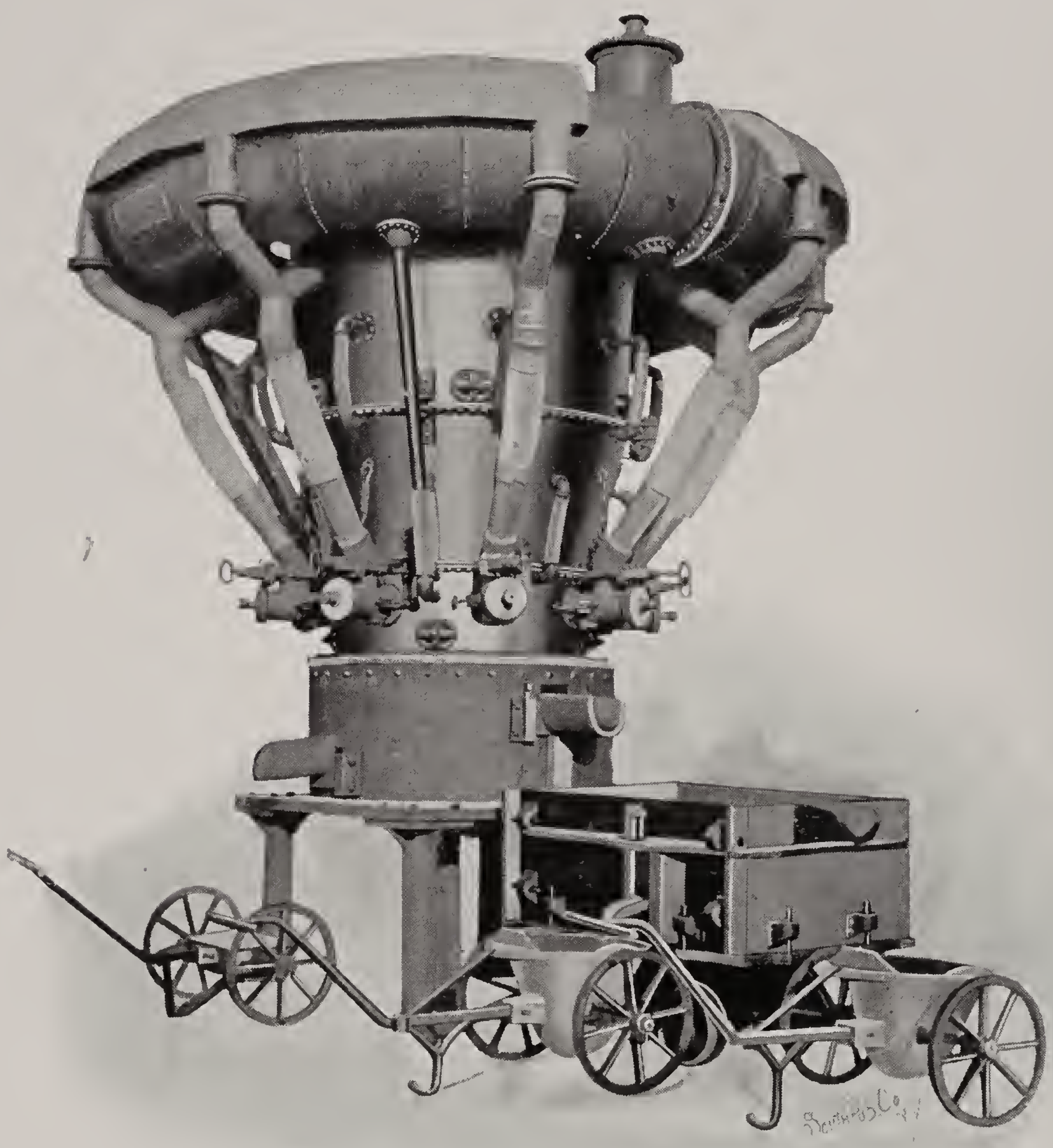


FIG. 75. 42″ ROUND COPPER BLAST FURNACE.

The Nesmith patent jacket water vaporizer is shown in place on this furnace, and this minimizes the amount of sediment deposited, both by reducing the amount of water used and by the settling of solids in the drum. The vaporizer drum has an air jacket built upon it for the purpose of warming the blast, but the amount of heat which can be put into the air by this means has proved small and the complication of the blast piping is considerable.

Copper Blast Furnace.

The chief recommendation of the round furnaces shown in Figs. 76 and 77 is lower first cost than the others illustrated, but as there are places where they will serve, and as we are called upon to furnish them occasionally, we continue to show them.

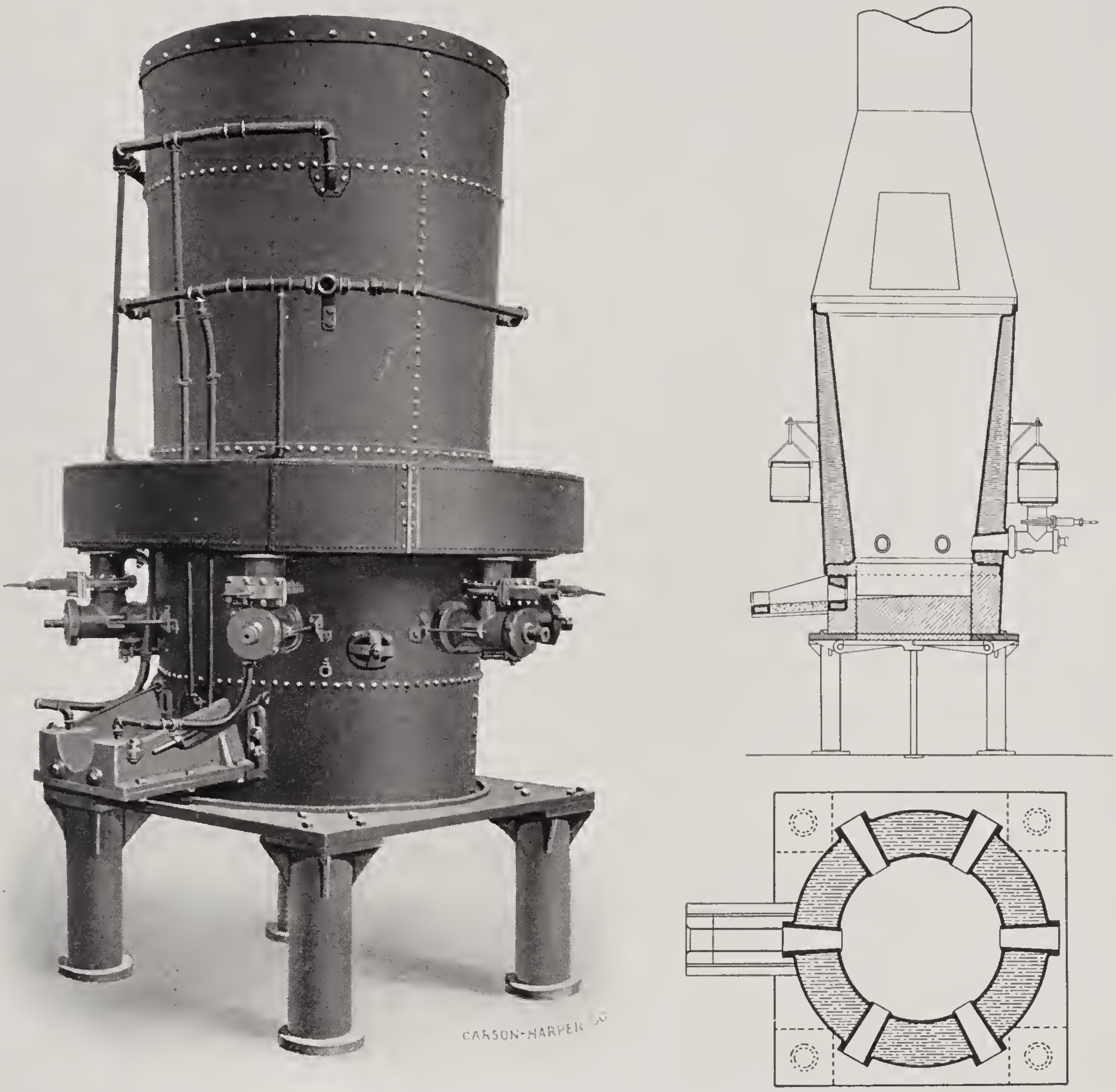


FIG. 76. 36″ ROUND COPPER BLAST FURNACE.

The jacket in both of these furnaces is in one piece with one vertical seam on the fire side, the outer sheet being extended downward to form the curb of the crucible. The furnace shown as Fig. 76 has our tuyeres with individual built-in valves, a spout with jacketed tip, and is more substantial in these respects than the furnace designated as Fig. 77, which, while retaining the best of material and workmanship throughout, is intended to be the cheapest that can be furnished for real work.

Copper Blast Furnace.

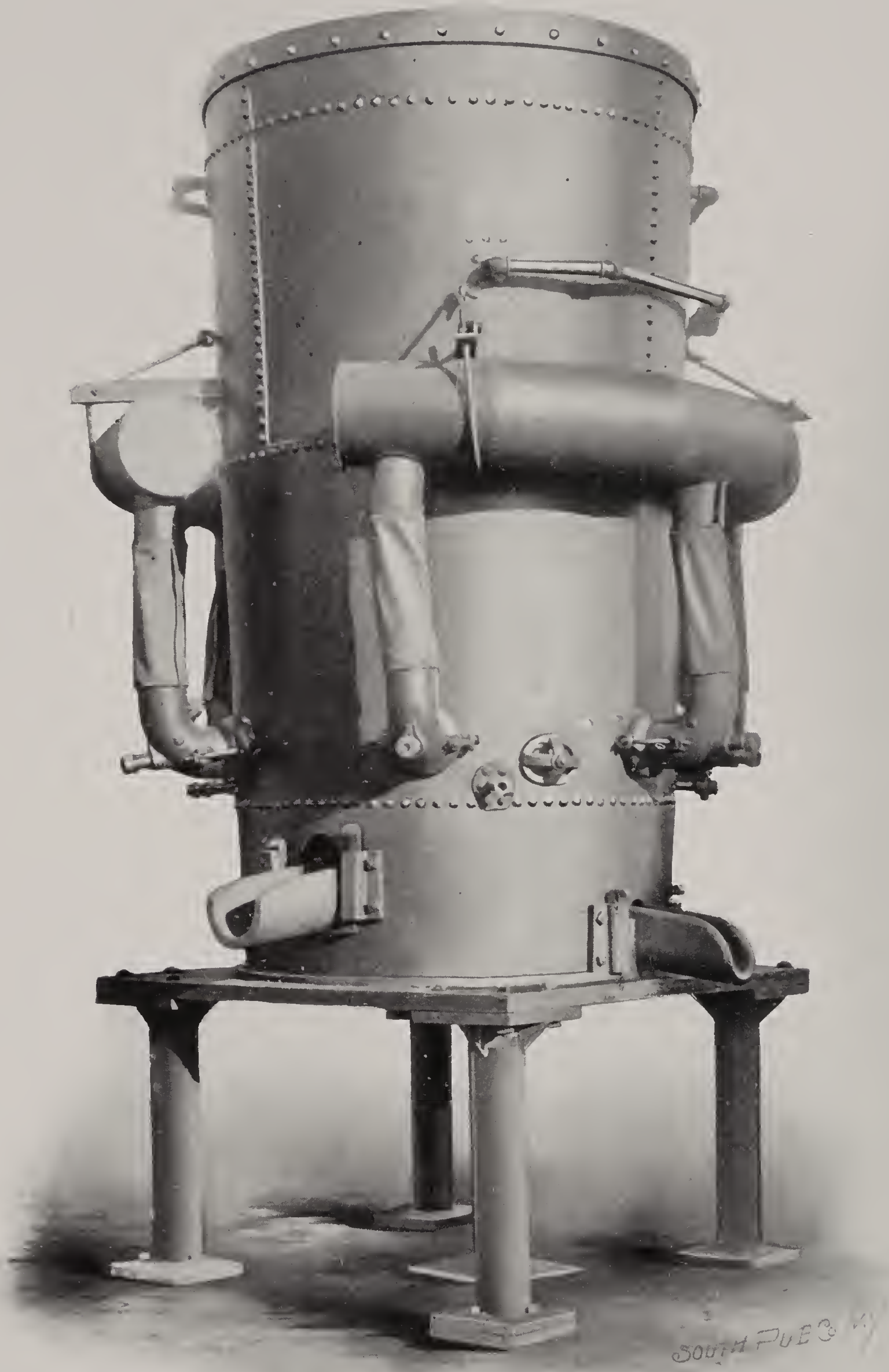


FIG. 77. 36″ ROUND COPPER BLAST FURNACE.

Dust Chambers.

The dust chamber here illustrated is an efficient and popular one, especially in connection with copper matting furnaces. In copper matting practically all of the values carried out of the furnace by the escaping gases are in the form of solid dust particles which settle with comparative readiness when subjected to relatively undisturbed conditions. This is accomplished by passing the gases through a flue or chamber of such large cross sectional area that their velocity is low and sufficient time is therefore allowed in which the particles

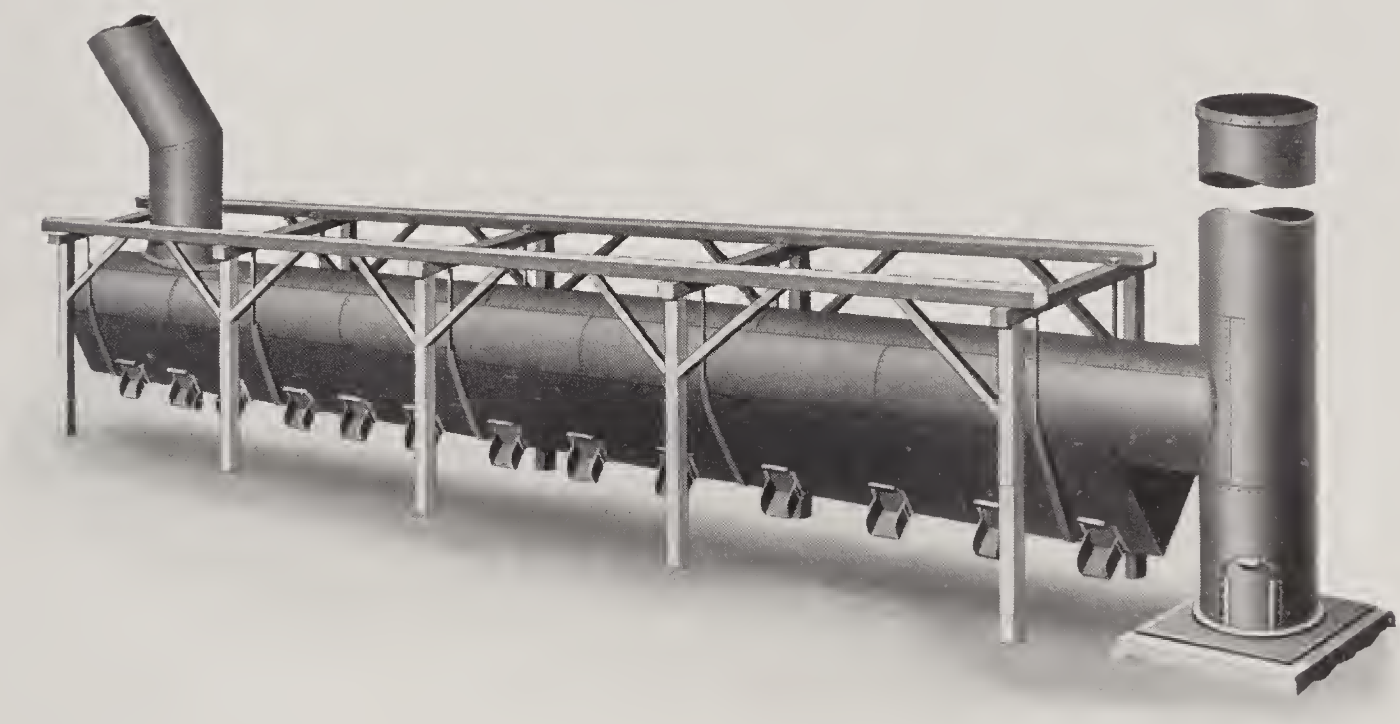


FIG. 78. BALLOON SHAPED DUST CHAMBER.

can settle through the distance necessary to reach the bottom where they remain until withdrawn.

The flue is balloon shaped in cross section, made in any diameter from four to ten feet, and of suitable length. Draw-off gates are placed at intervals along the bottom, from which the accumulated flue dust is conveniently drawn into wheelbarrows, although with flues of very large diameter, collecting a great amount of dust, we can furnish them with a screw conveyor in the bottom which conveys the dust to one end of the flue and deposits it, thus eliminating a large amount of manual labor.

The preferred location for the dust flue is on the feed floor level, where it is suspended, leaving ample head room beneath it.

Blast Furnace Superstructures.

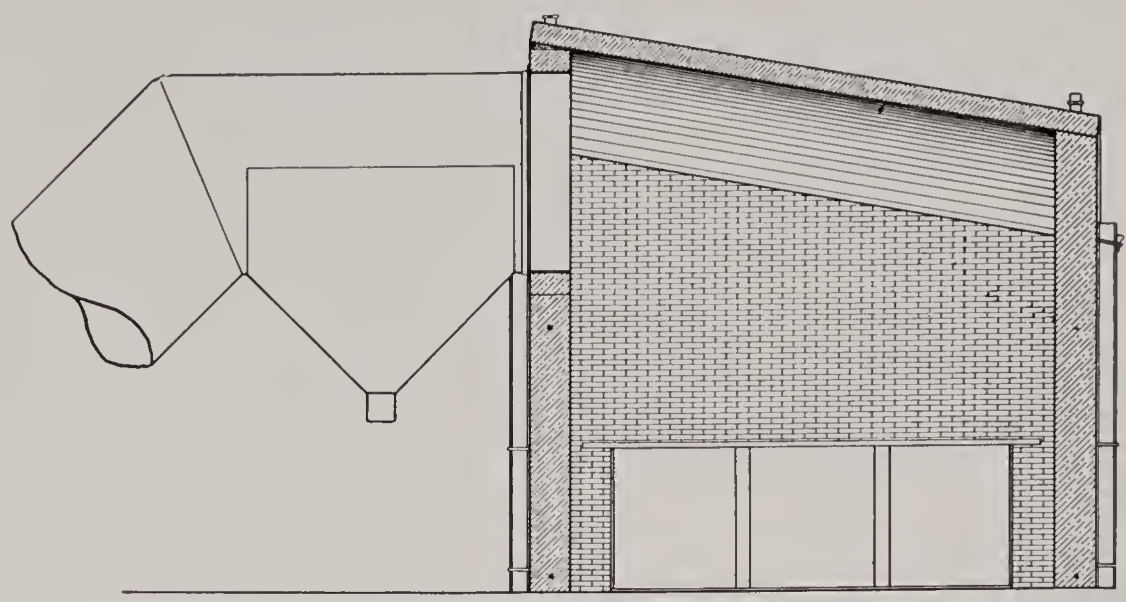


FIG. 79. BRICK SUPERSTRUCTURE FOR COPPER MATTING FURNACES.

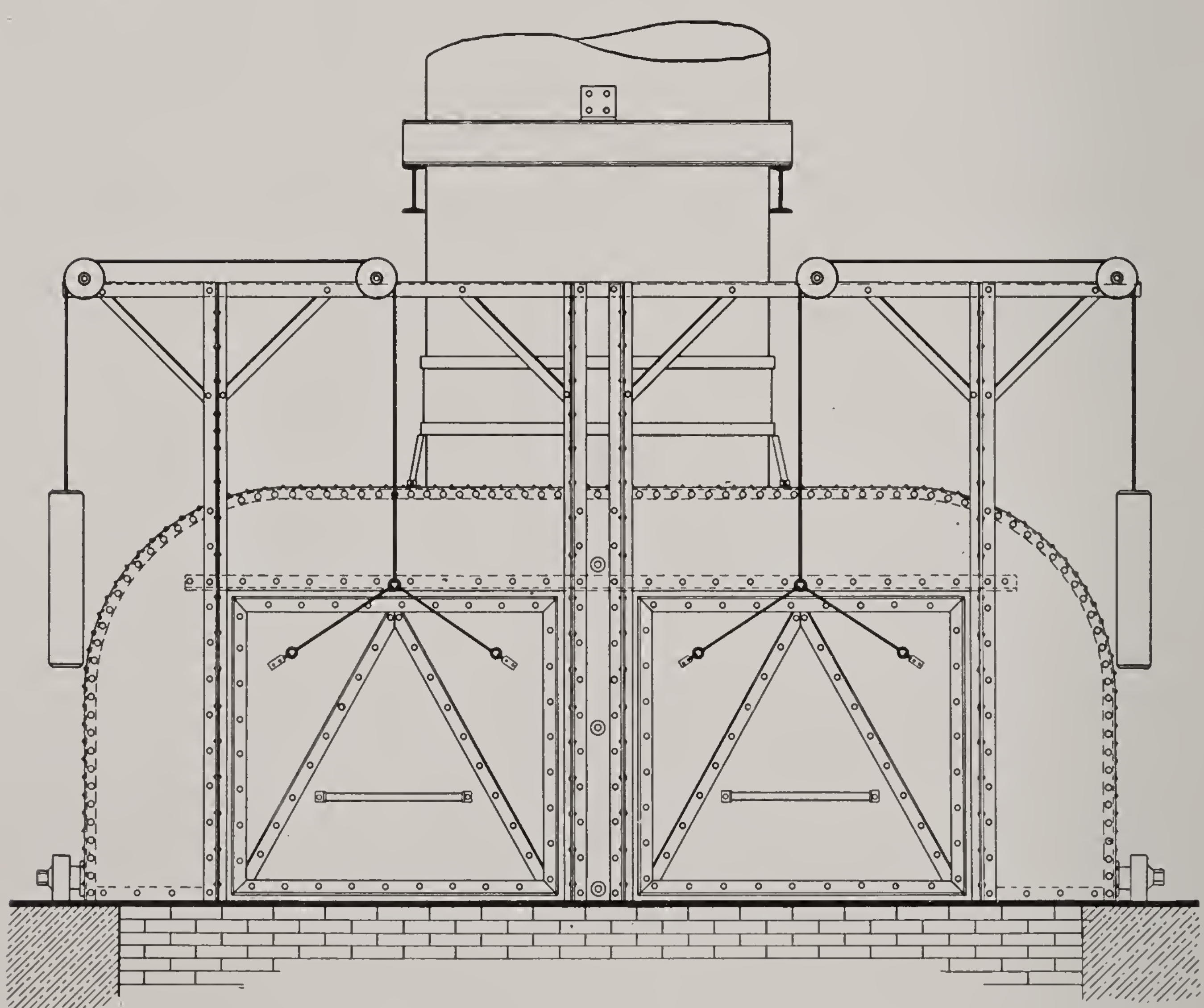


FIG. 80. MOVABLE STEEL HOOD FOR LEAD BLAST FURNACES.

Blast Furnace Hoods.

In Fig. 79 is shown a very desirable form of brick and sheet steel superstructure, particularly so for copper matting furnaces running with a hot top, and where a dust chamber is used.

The structural materials used immediately above the furnace shaft being brick and cast iron are those best suited to withstand the high temperature to which they are subjected, and the sheet steel flue may be lined with brick for whatever distance is necessary. In

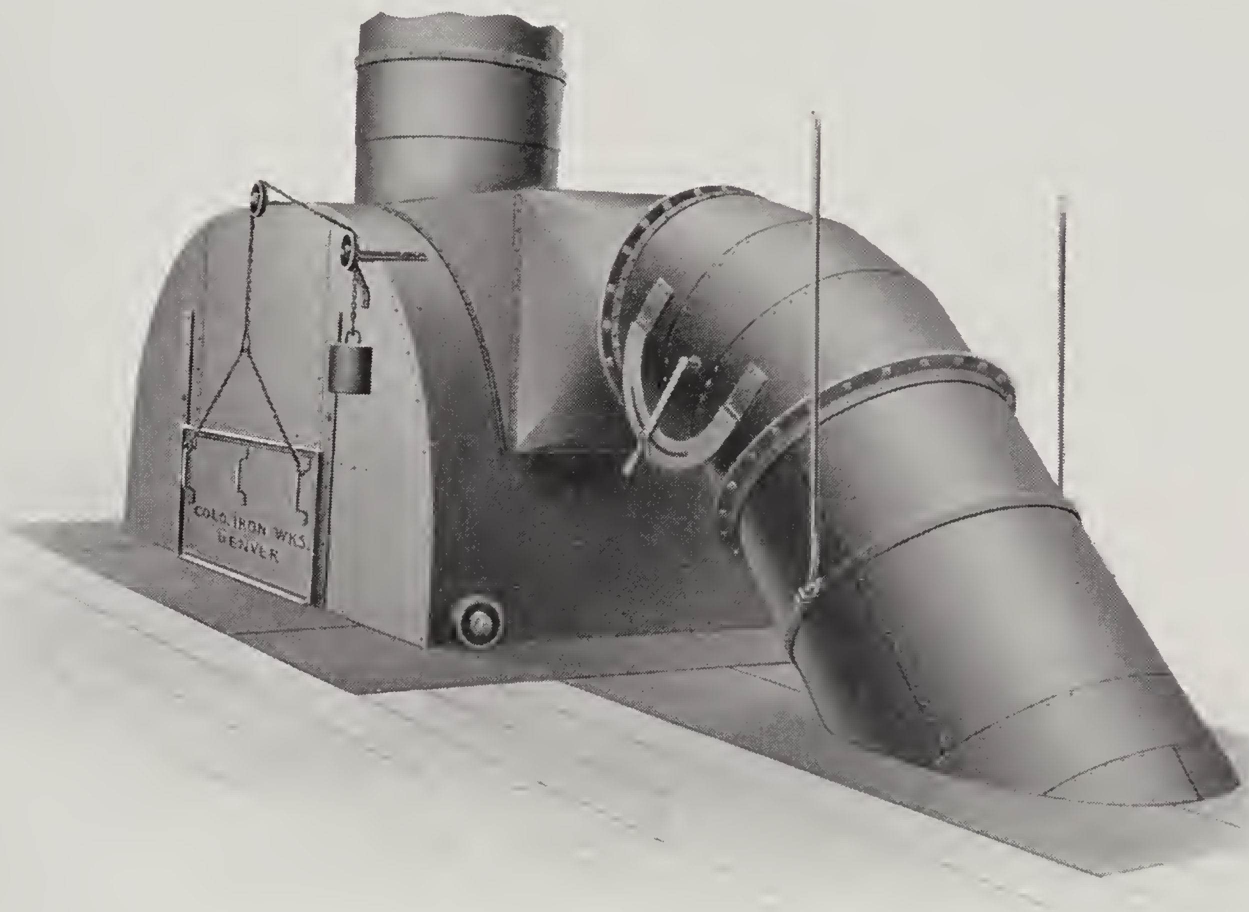


FIG. 81. MOVABLE STEEL HOOD FOR LEAD BLAST FURNACES.

copper matting furnaces which are driven hard a large proportion of the flue dust is relatively coarse and settles rapidly. The hopper bottom to the first section of the downtake provides simple means for collecting this coarse material. A hood of this kind is shown on the furnace illustrated in Fig. 63.

The movable steel hoods shown in Figs. 80 and 81 are particularly adapted to lead furnaces. They have a wheel at each corner on an eccentric axle. When the hood is to be moved aside to give access to the furnace shaft for barring down, the telescoping sleeve forming connection with the fixed portion of the stack is disconnected, the hood raised on the wheels by operating the eccentric axles and rolled aside, leaving the entire top of the furnace shaft exposed, the fumes passing largely off by the stack. Although the first cost of this hood is greater than that of the iron work as usually furnished for a brick super-

structure, when the cost of erection is considered there is practically no difference in the final cost.

The illustrations on this page are from photographs of hoods for small furnaces. Fig. 82 is of a hood for a round copper furnace and presents the general features of the type most commonly used. This hood is circular in plan and is made entirely of sheet steel. There are two charging doors placed opposite each other and provided with counter balancing weights so arranged as to make the entire hood self-contained. These charging doors do not conform to the curvature of the hood but are flat, thus reducing the tendency to warp and bind. This type of hood is also generally supplied with our polygonal copper furnaces although we sometimes furnish a hood with doors hinged at their upper ends as shown in Fig. 54.

FIG. 82. FURNACE HOOD.

The hood shown in Fig. 83 is for a small rectangular lead furnace and is of a design which leaves little to improve upon. The lower part is pyramidial in shape and conforms to the lines of the shaft. This enables the charging doors to be placed on the sloping sides where their weight retains them in contact with the ways in which they slide, and permits open slide ways to be used, thus eliminating binding due to warping.

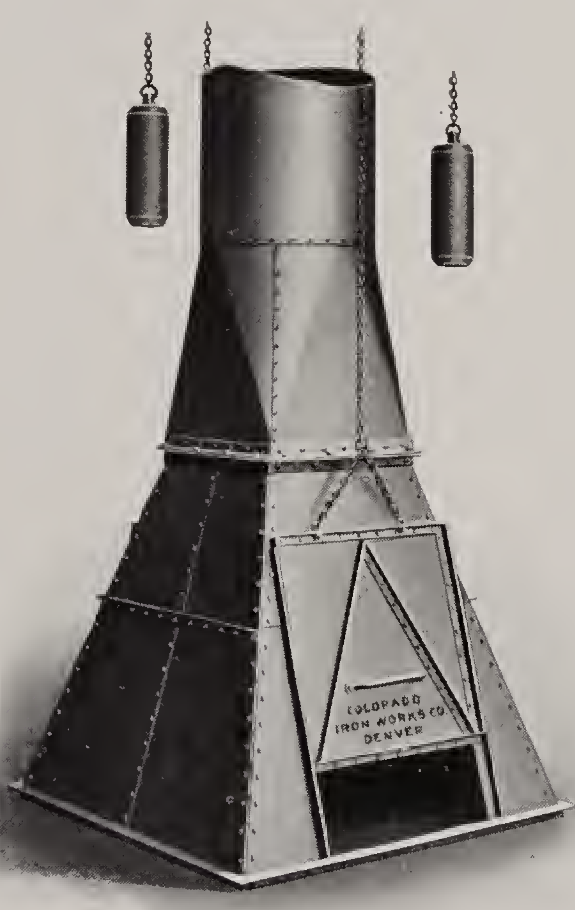


FIG. 83. FURNACE HOOD.

The telescoping hood shown on the furnace illustrated in Fig. 30 has the advantages that the charges can be shoveled into the furnace from any point and that raising the hood gives access to the entire interior.

Positive Blowers.

The manufacture of blowers is a specialty. The Connersville Blower Co., whose blowers we have sold for many years, has developed a machine which for efficiency, reliability and durability meets the most exacting demands. We believe satisfaction with them has been universal, and we continue to recommend them without qualification.

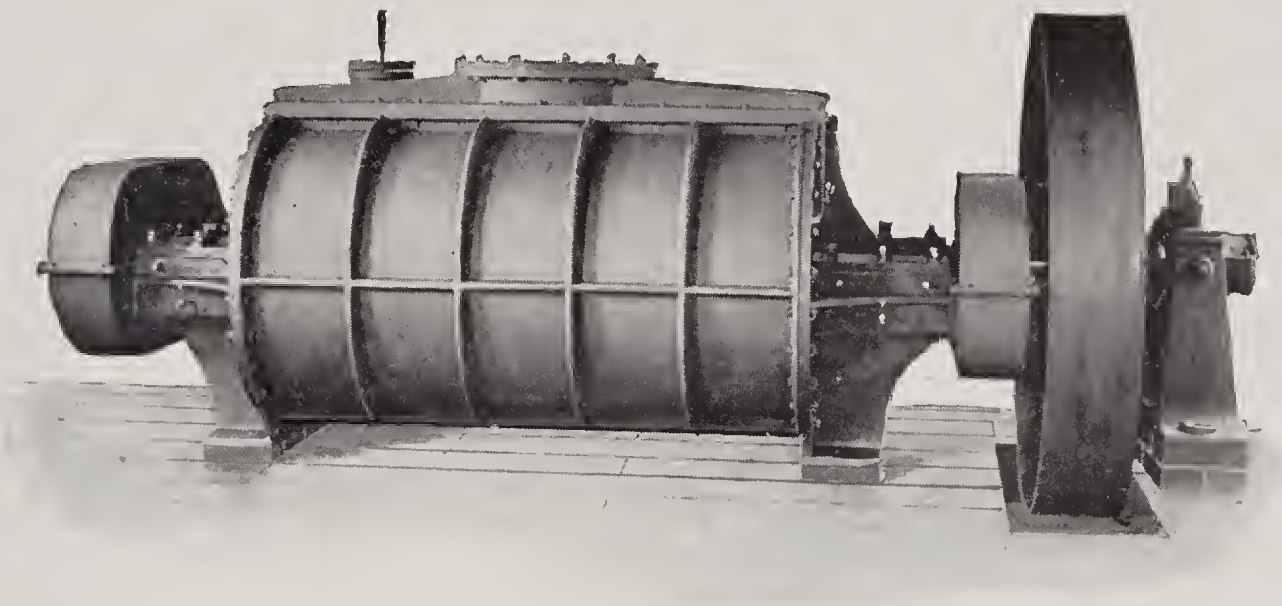


FIG. 84. CONNERSVILLE POSITIVE BLOWER.

This type of blower is the best for lead and copper smelting, showing higher efficiency at the pressures used in that work than either fans or blowing engines, and without the uncertainty in volume delivered by the former. The power is practically proportional to the displacement and pressure and tests have shown that, when operating against a pressure of 32 to 56 ounces, from 84 to 86 per cent. of the indicated horsepower of the engine is transformed into energy in the blast. The power required may be taken at five horsepower for each 1,000 cubic feet free air per minute at one pound pressure.

The regular sizes are as follows:

SIZES, SPEEDS, WEIGHTS, ETC., OF CONNERSVILLE BLOWERS.

Displacement Cubic Feet	Speed R. P. M.	Size Pulley Inches	Horsepower at 32 Oz.	Outlet Diameter	Weight Pounds
13	250	42 x 7	32	14-in.	6,000
17	225	42 x 8	38	16-in.	7,400
24	200	48 x 10	48	18-in.	9,000
33	190	60 x 12	62	20-in.	13,300
45	180	66 x 14	81	20-in.	16,000
57	170	72 x 16	97	24-in.	20,000
65	160	84 x 16	104	24-in.	23,700
84	150	84 x 20	126	27-in.	26,000
100	140	96 x 20	140	30-in.	36,000
118	130	120 x 20	153	30-in.	42,000

Blast Gates.

FIG. 85. BLAST GATE.

Our blast gates are constructed in the same manner as a water gate, with the pressure on one side. They are well designed and thoroughly fitted, the valve stem works through a stuffing box and the entire valve is air tight.

We have patterns for the style shown in Fig. 85 in all regular sizes from twelve to thirty inches in diameter.

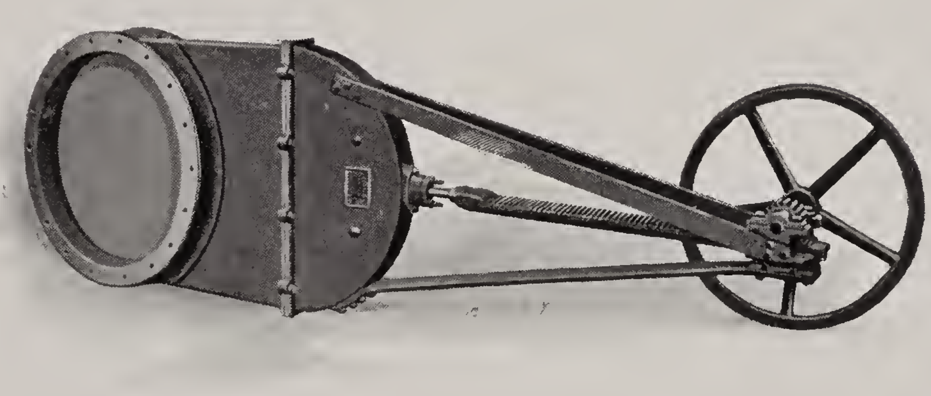


FIG. 86. RACK AND PINION BLAST GATE.

The lower illustration on this page shows the gate with a rack and pinion operating mechanism. We are prepared to furnish all sizes to work by a hand wheel in this manner, but the attachment is only desirable in gates twenty-four inches in diameter and over.

The engraving on this page shows an improved type of rack and pinion actuated gate. It is well ribbed to prevent springing of the parts with consequent leakage of air. The body parts are planed where they fit together and the pinion shaft is fitted with a stuffing box, making the entire gate air tight. The rack is cast integral with the valve, is planed on the sides, and slides in a groove planed in the body, thus forming a guide. The gate also bears two broad ribs at the

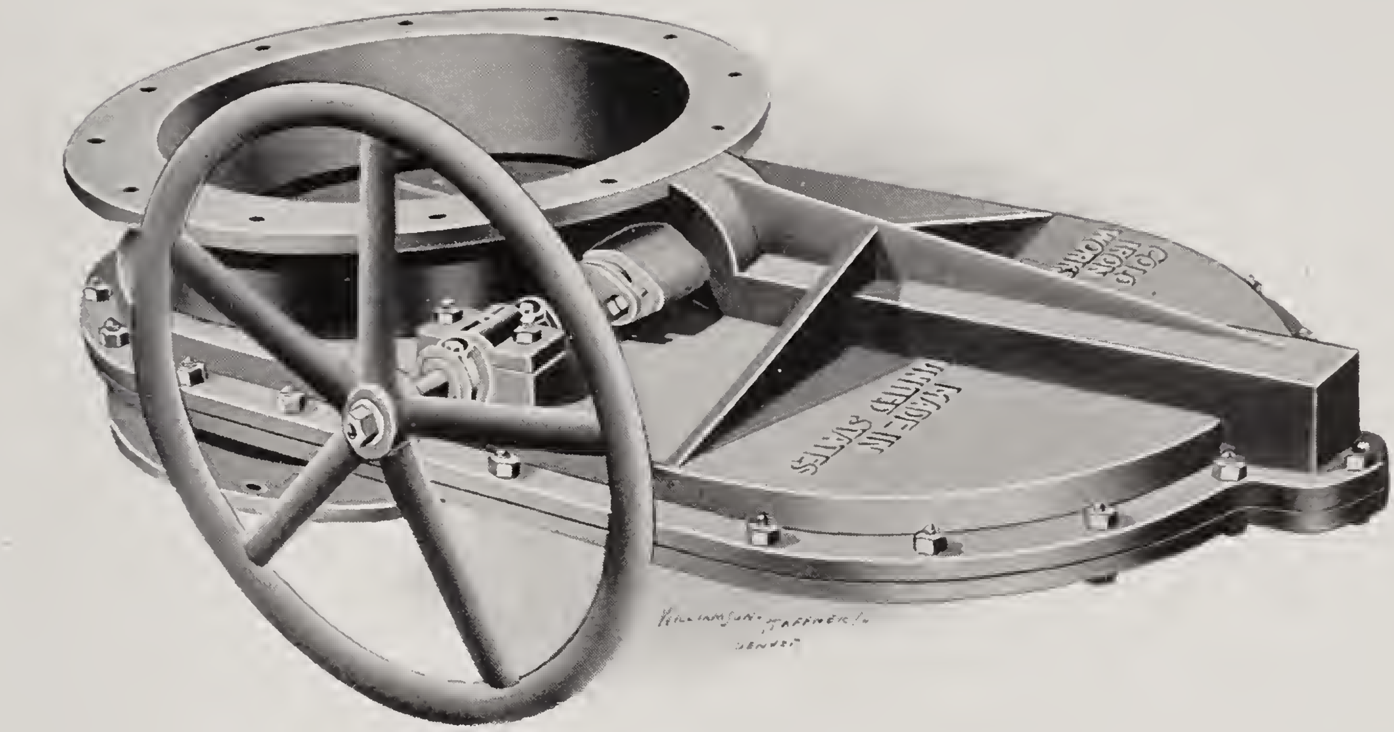


FIG. 87. RACK AND PINION BLAST GATE.

sides of the rack which are also planed and slide between two corresponding finished surfaces on the inside of each half of the body.

A blast gate made in this way is very compact and durable, but is necessarily more expensive to build than our other type of rack and pinion gate. Where blast gates are opened and closed frequently and rapidly, this is the best type of gate on the market, as it is easily operated even under heavy blast pressure.

We can furnish this gate in the principal sizes, 15, 18, 20, 24 and 30 inches diameter.

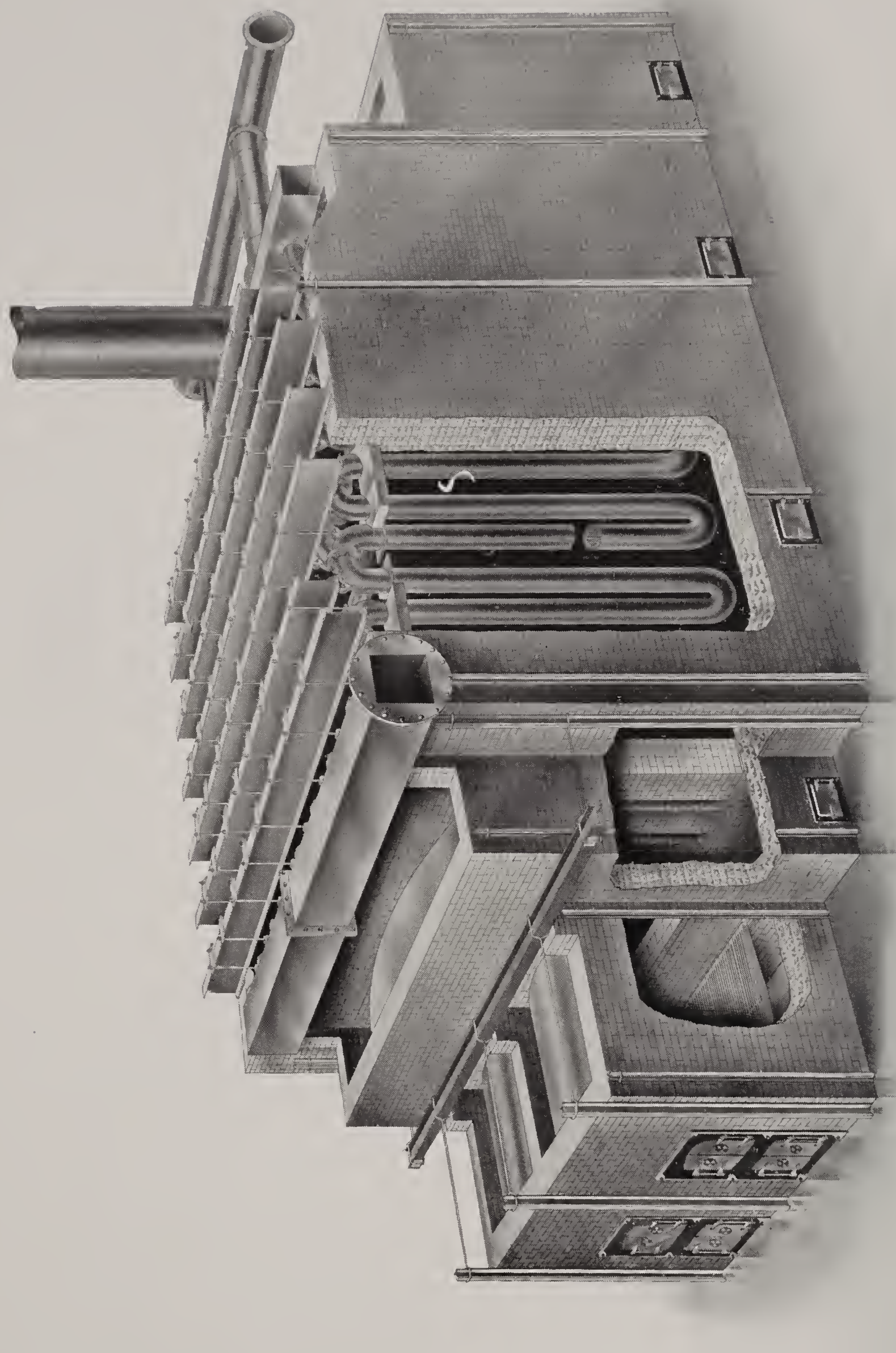


FIG. 88. U-PIPE HOT BLAST STOVE.

Hot Blast Stoves.

There are no combustible gases escaping as waste from the copper or lead blast furnaces which could be utilized as fuel for preheating the blast. Therefore, the Siemens regenerative or brick checkerwork stove can not be used, and the heating must be performed in some other apparatus, suitable for burning other fuel.

The U-pipe stove, substantially as described and illustrated here, was the best in design and construction ever used for heating the blast in iron smelting before the introduction of the Siemens regenerative stove, and a knowledge of the facts caused us to adopt this design in the first stoves we built for use in copper smelting.

This principle had been so well worked out by iron smelters that we have retained it, and we have added only such improvements as several years' experience has shown to be of undoubted worth. These improvements relate not only to efficiency, but to durability and convenience in operation and repair.

The plan is one which lends itself to easy attainment of any desired capacity and the entire apparatus is of such simple design and substantial construction that it forms a most reliable item in the equipment of a smelting plant.

Attempts upon the part of others to make U-pipe stoves have resulted in failure to such a degree as to cause a lack of confidence in them upon the part of some metallurgists. These attempts have involved departures from two very necessary details of construction, which were made in the interest of cheapness without a realization of the consequences which must necessarily follow.

The two necessary features to which we refer are: The pipes must not be exposed to the intense flame in the vicinity of the fire box, and proper provision for expansion and contraction must be made, the former to prevent local burning through of the pipes and the latter to avoid their breakage or leakage in the joints. Other attempts we have seen, embodying joints within the stoves, the substitution of welded steel pipe for cast iron, etc., were such wide departures from the evident requirements that they need not be discussed.

Properly designed and built, and operated with ordinary care, the U-pipe stove is not more subject to stoppage or accident than is the blast furnace or the roasting furnace or other apparatus forming parts of the complete smelting plant.

Air, in common with other gases, is a very poor conductor of heat, and when a mass of it is to be raised in temperature the heat is communicated to the part remote from the heated contact surface mainly by currents causing circulation within the mass.

To provide greater contact surface than the plain pipes formerly used, we devised and patented our special U-pipe with internally projecting ribs. This is shown in cross section in Fig 92. These pipes have double the internal surface of plain pipes of like diameter, making our stove so much more efficient that but half the length of pipe is required. Here the purchaser gains by the saving of a

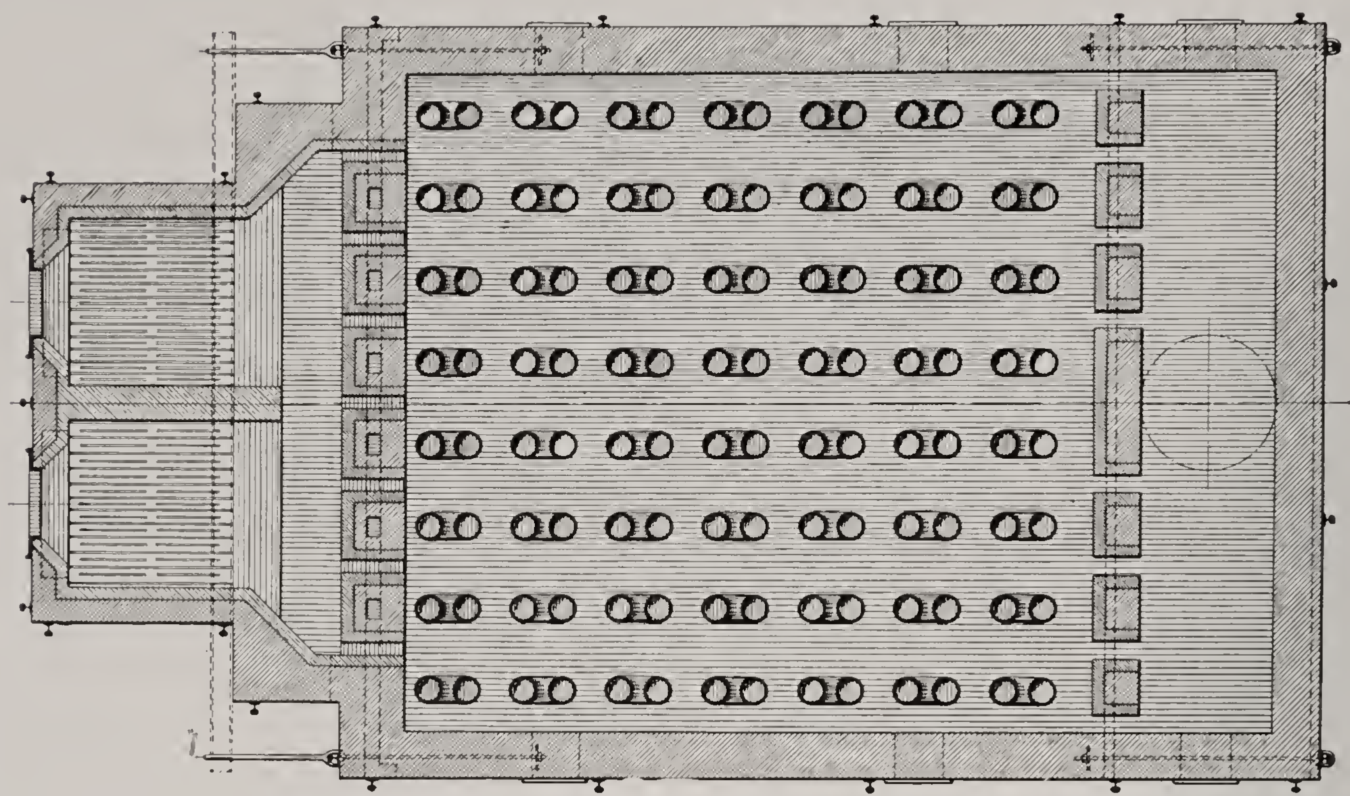


FIG. 89. PLAN OF U-PIPE HOT BLAST STOVE.

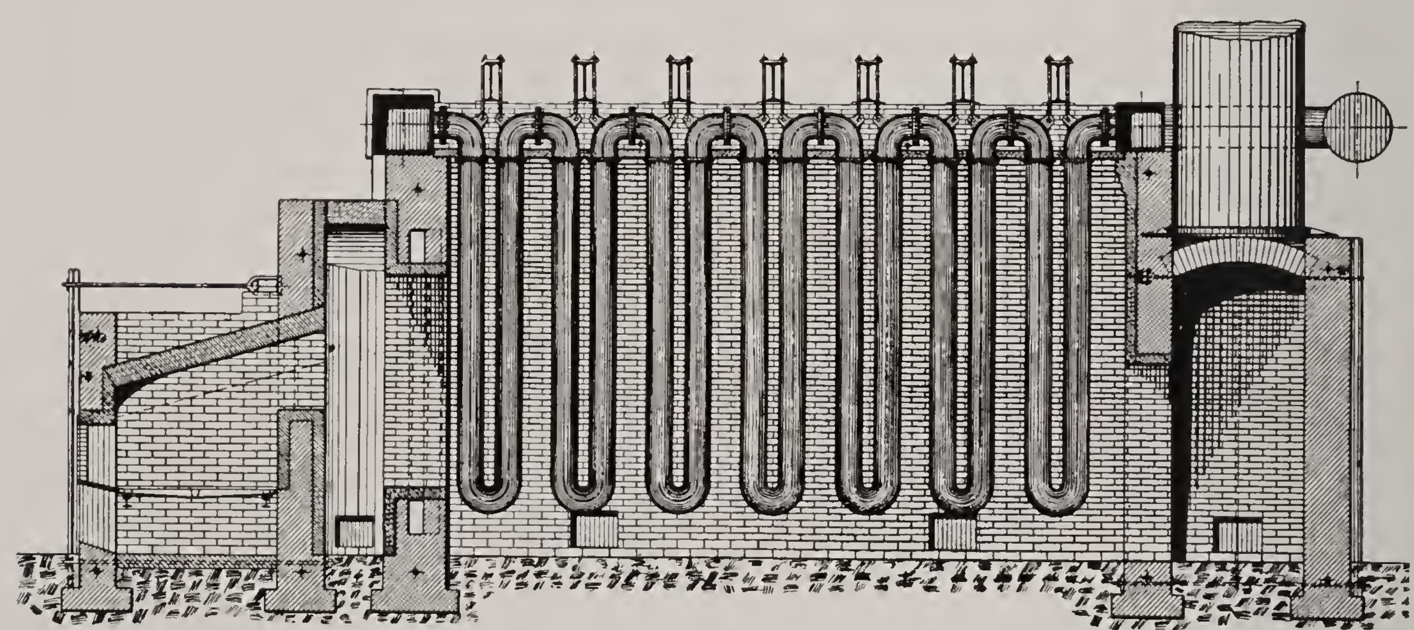


FIG. 90. SECTIONAL ELEVATION OF U-PIPE HOT BLAST STOVE.

large amount in first cost and expense of installation. A further improvement, more recently added, is an enlargement of the pipe at the bends to increase the area and reduce friction. Our present U-pipe is therefore as illustrated in Fig. 91.

The complete stove consists of a number of pipes usually made up in sections of four series, each series comprising 6, 7 or 8 pipes, thus making a total of 24, 28 or 32 pipes. The number of pipes in each series depends on the desired time of contact and the number

of series and sections is determined by the velocity of the air passing through the pipes.

The pipes are planed where they are connected together, and are coupled up with asbestos gasgets, making air-tight joints. They are flexibly supported from I-beams carried by the brick walls and are free to adjust themselves to take up expansion and contraction.

The blast enters the series of pipes through a rectangular cast iron manifold at the rear end of the stove and leaves it by a similar but larger manifold at the front or fire-box end. The manifolds are usually bricked in, or covered with asbestos cement, to prevent loss of heat by radiation.

FIG. 91. U-PIPE.

Below the elbows on the U-pipes are flanges, shown in Fig. 91. When the pipes hang in place these are all on a level, and upon them are placed special fire clay tiles. Upon these tiles is a filling of ashes, covering the entire ends of the pipes which project above the tiles. This forms a cheap insulation, and when a pipe is to be replaced the ashes are removed where necessary and the tiles which rest on the pipe to be changed are lifted off. All bolts being outside the heating chamber, it is unnecessary to enter the stove at any time, and repairs, which are infrequent, can be rapidly made. During the making of such repairs it is not necessary to shut down the blast furnace, but only to run it temporarily on cold blast.

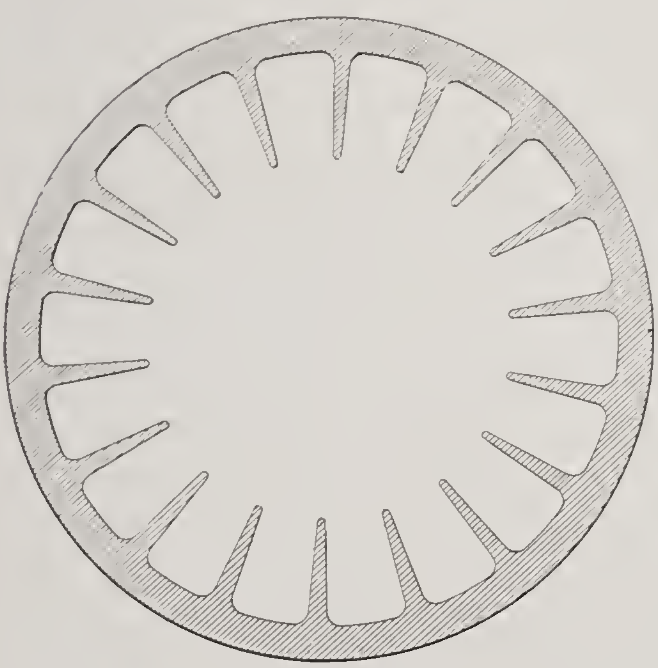


FIG. 92. U-PIPE.

A proper design of the brickwork prevents the intensely hot gases from the fire box from impinging on the pipes and as our U-pipes do not break from temperature changes, we feel we can safely claim to furnish a stove free from defects and capable of giving highly efficient service under actual operating conditions.

Lead Coolers.

The lead cooler shown in the engraving on this page is designed to receive the lead from a blast furnace instead of ladling it directly into moulds. We recommend it as it makes it possible to ship a cleaner bullion by skimming before moulding.

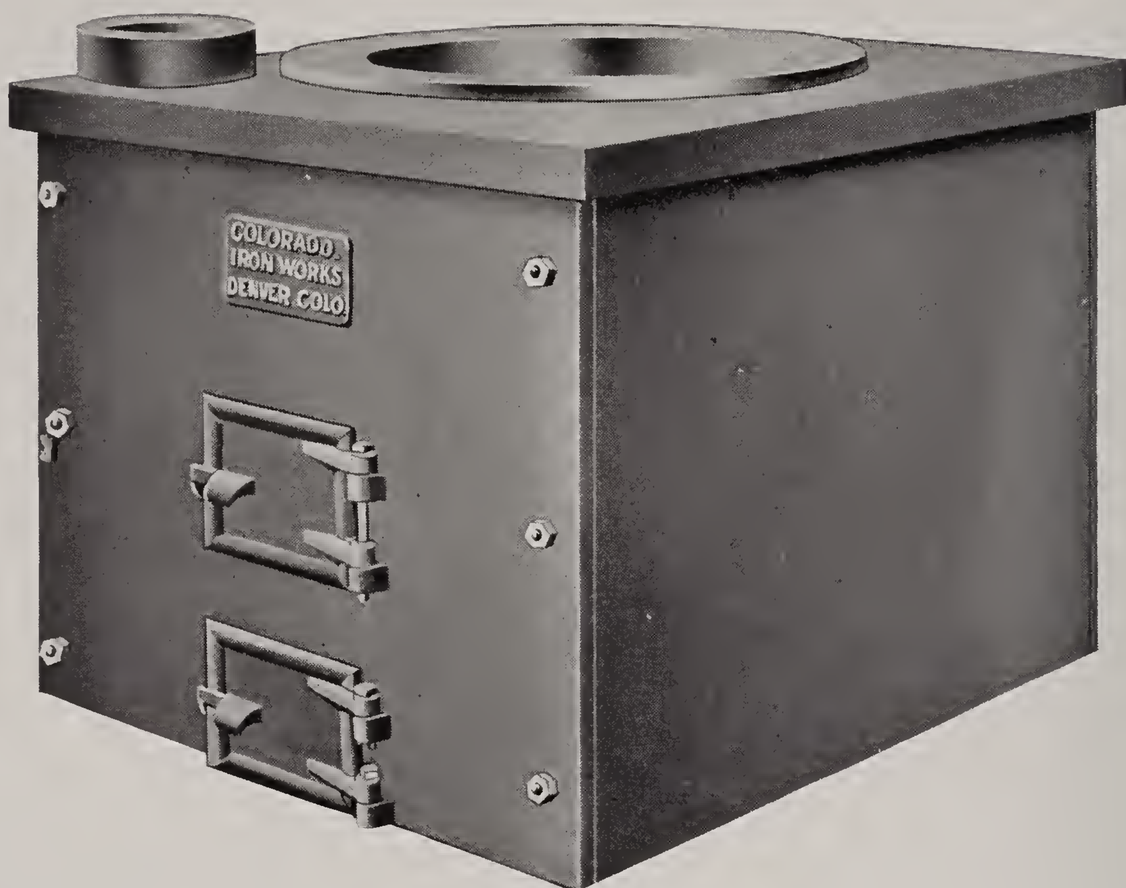


FIG. 93. LEAD COOLER.

The lead cooler consists of a lead kettle with fire box beneath, enabling the lead to be kept in perfect liquid condition for the removal of dross.

We usually supply them in one of two sizes, with kettles respectively 20 inches in diameter by 12 inches deep and 26 inches diameter by 17 inches deep. They are of cast iron plates, very heavy, and designed to have a brick lining. They are assembled before shipment and are furnished with grate bars and stack.

Forehearths or Settlers.

The engraving on this page shows our standard form of portable forehearth or matte settler used with the smaller and moderate sized furnaces. For large furnaces, especially where matte storage is required for a converting plant, the stationary forehearth is generally used.

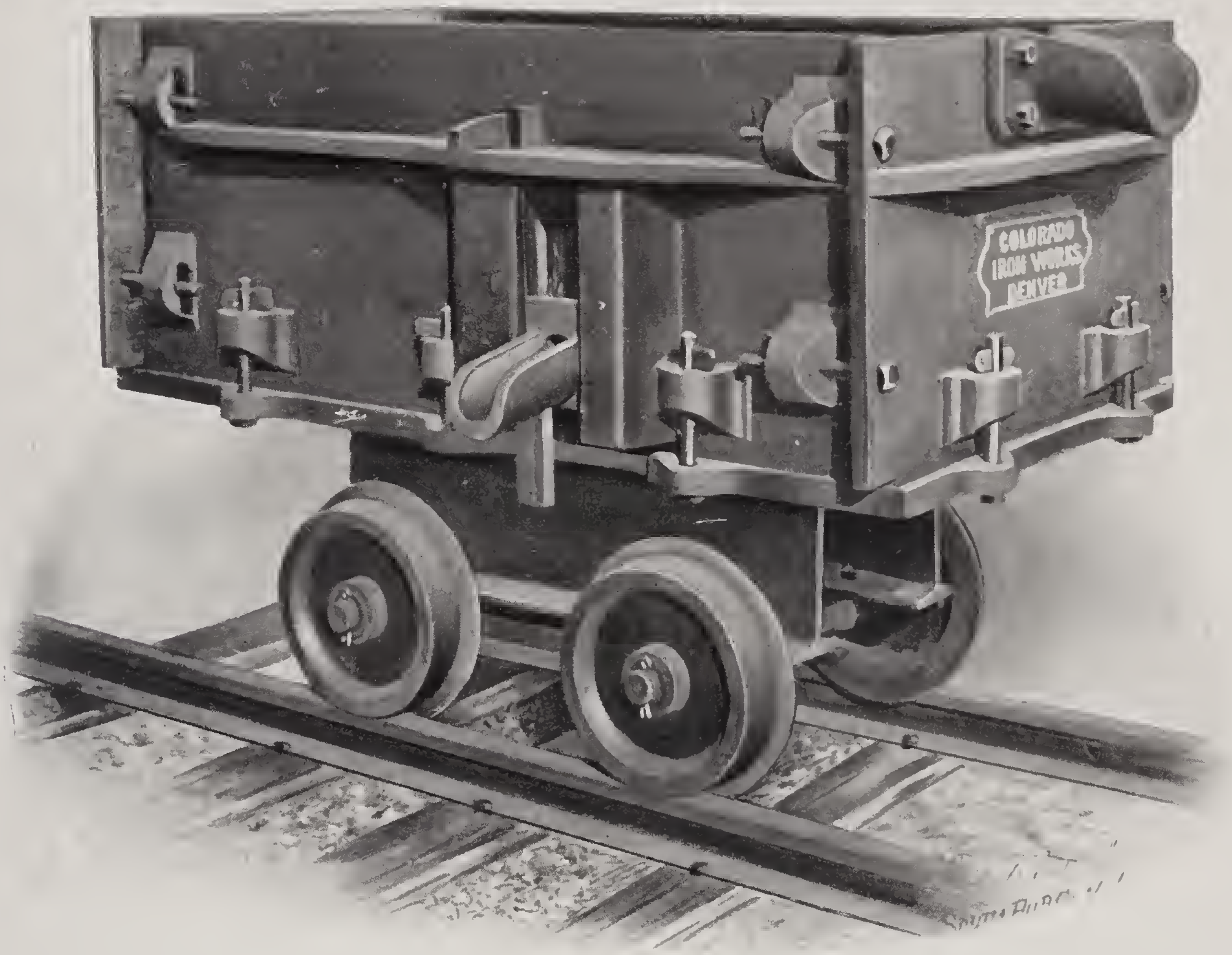


FIG. 94. 58″ x 32″ x 24″ PORTABLE FOREHEARTH OR SETTLER.

This portable forehearth has a body made of heavily ribbed cast iron plates bolted together, ready for the fire brick lining. The spout is removable and an adjustable matte tapping block with cooling pipe cast inside is provided. It is very heavily built and adapted to withstand the temperature changes and rough usage to which it is liable to be subjected.

We build this forehearth in the following sizes:

36 inches wide, 54 inches long, 30 inches deep.
36 inches wide, 72 inches long, 36 inches deep.
48 inches wide, 60 inches long, 30 inches deep.
72 inches wide, 72 inches long, 36 inches deep.

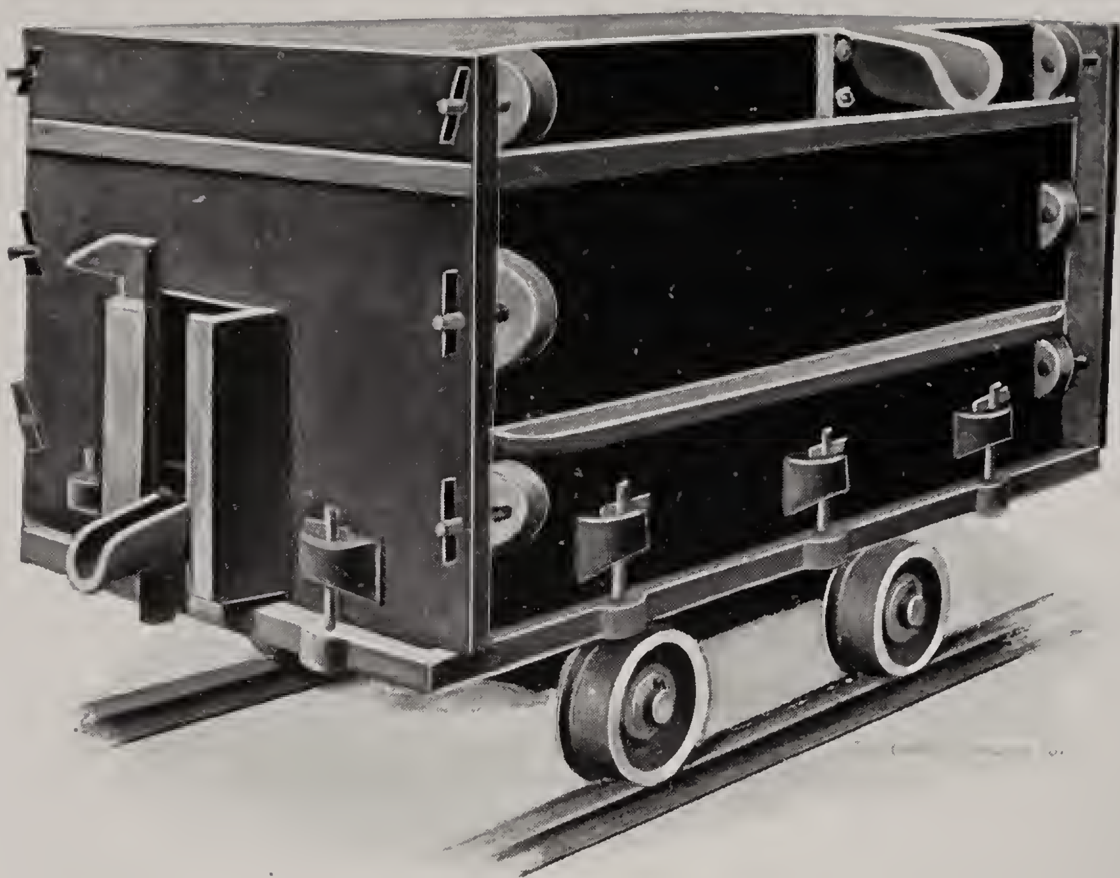


FIG. 95. 72″ x 36″ x 36″ PORTABLE FOREHEARTH OR SETTLER.

The above cut represents a form of forehearth for copper matting furnaces, with or without a turntable placed on the truck underneath the body. These are furnished in several sizes.

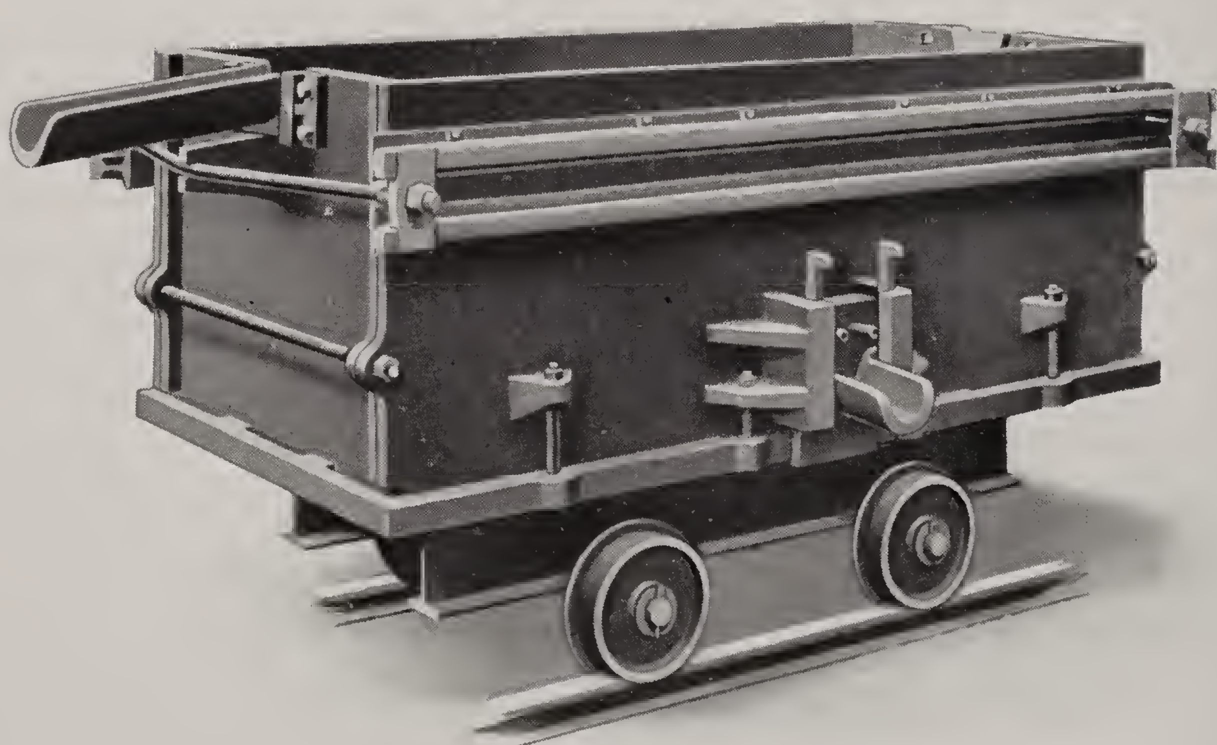


FIG. 96. 90″ x 42″ x 36″ PORTABLE FOREHEARTH OR SETTLER.

The illustration, Fig. 96, shows the manner in which our portable forehearths of the general design shown in Fig. 94 are constructed when of considerable length. The upper parts of the sides are stiffened by T-rails and the lower edges are carefully fitted inside of a flange cast around the edge of the bottom plate.

The matte tap is a heavy block of cast iron, with an extra heavy cooling pipe cast inside around the tap hole. Both this block and its spout are adjustable vertically, and are held in place by two gib head steel wedges.

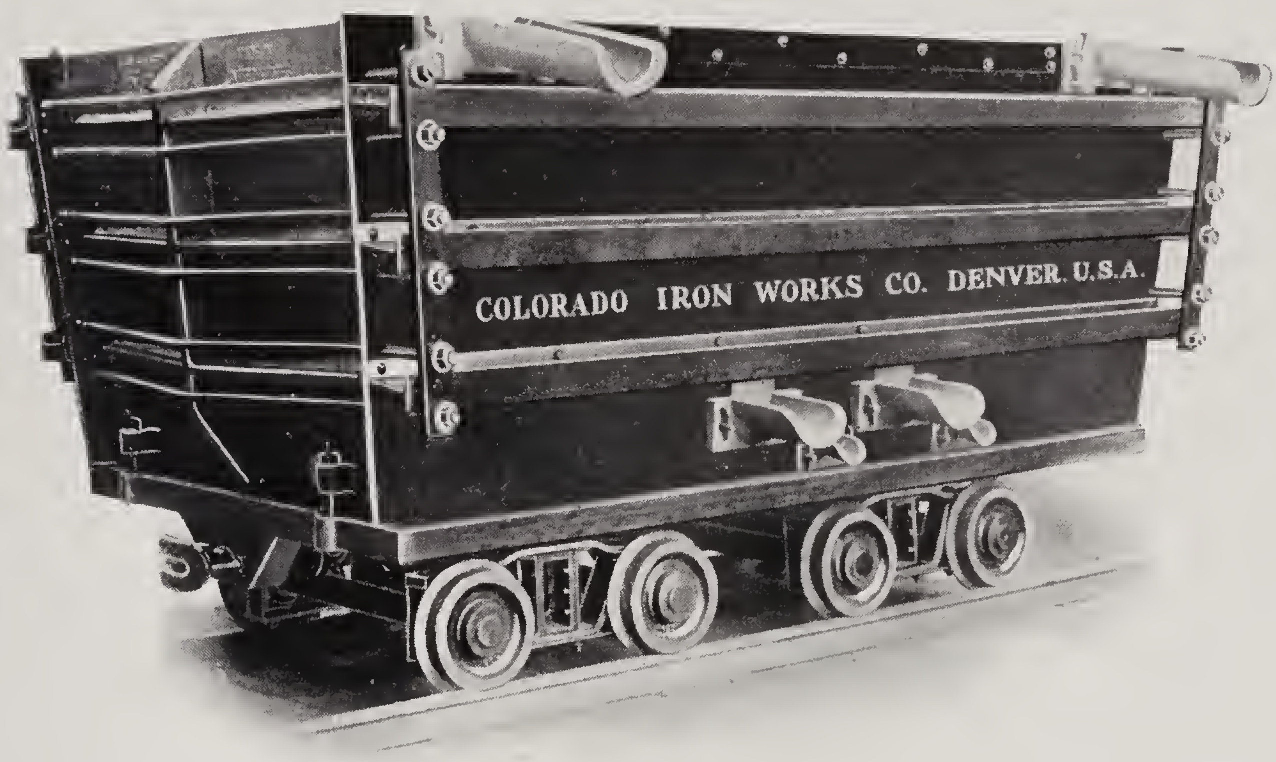


FIG. 97. 128″ x 79″ x 54″ PORTABLE FOREHEARTH OR SETTLER.

The above engraving is from a photograph of an unusually large portable forehearth three of which we built for a large foreign lead smelting plant. The body is 10 feet 8 inches long, 6 feet 7 inches wide and 4 feet 6 inches deep, inside measurement. In this instance they are used as matte and lead settlers, and for this reason they were provided with two taps on one side, one for the lead and one for the matte.

To secure the necessary strength notwithstanding their great length, the sides were made of one-half inch steel plate, strongly reinforced with heavy I-beams. The weight of the forehearths was necessarily great, and they were consequently mounted on swivel trucks of regulation pattern instead of upon four wheels as is usual with forehearths of smaller size.

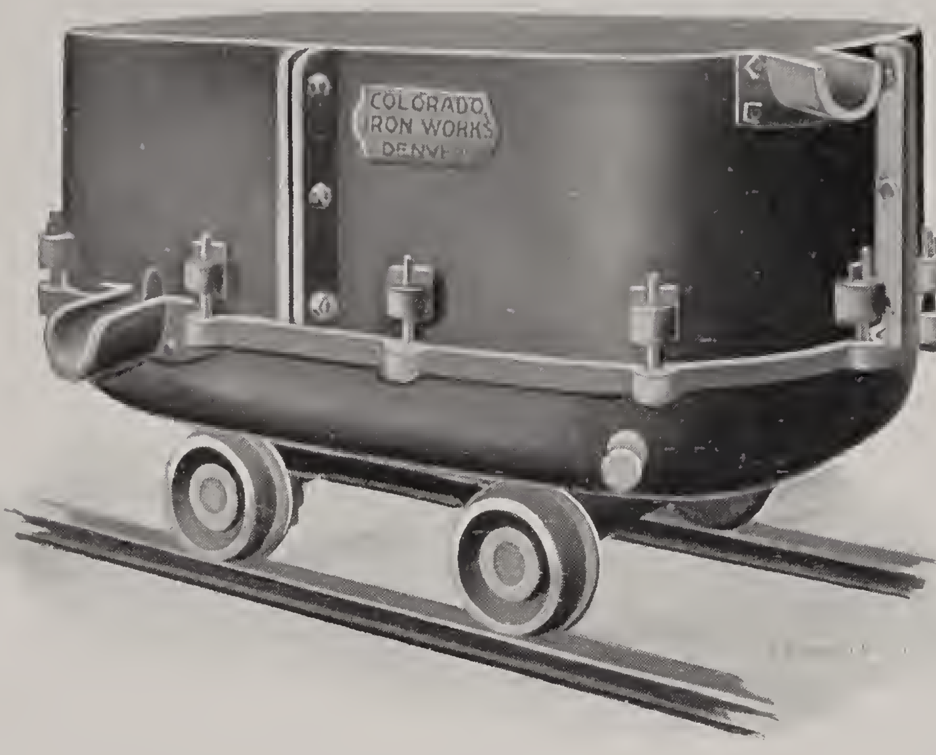


FIG. 98. 72″ x 42″ x 30″ SPECIAL PORTABLE FOREHEARTH.

The above engraving shows a type of forehearth sometimes used under the slag spout of lead furnaces to recover lead and matte carried out mechanically in the slag. It will be observed that the bottom of this forehearth is in the form of a pan. Molten lead is carried in this to receive the lead which settles out, the matte collecting in a layer on top of the lead.

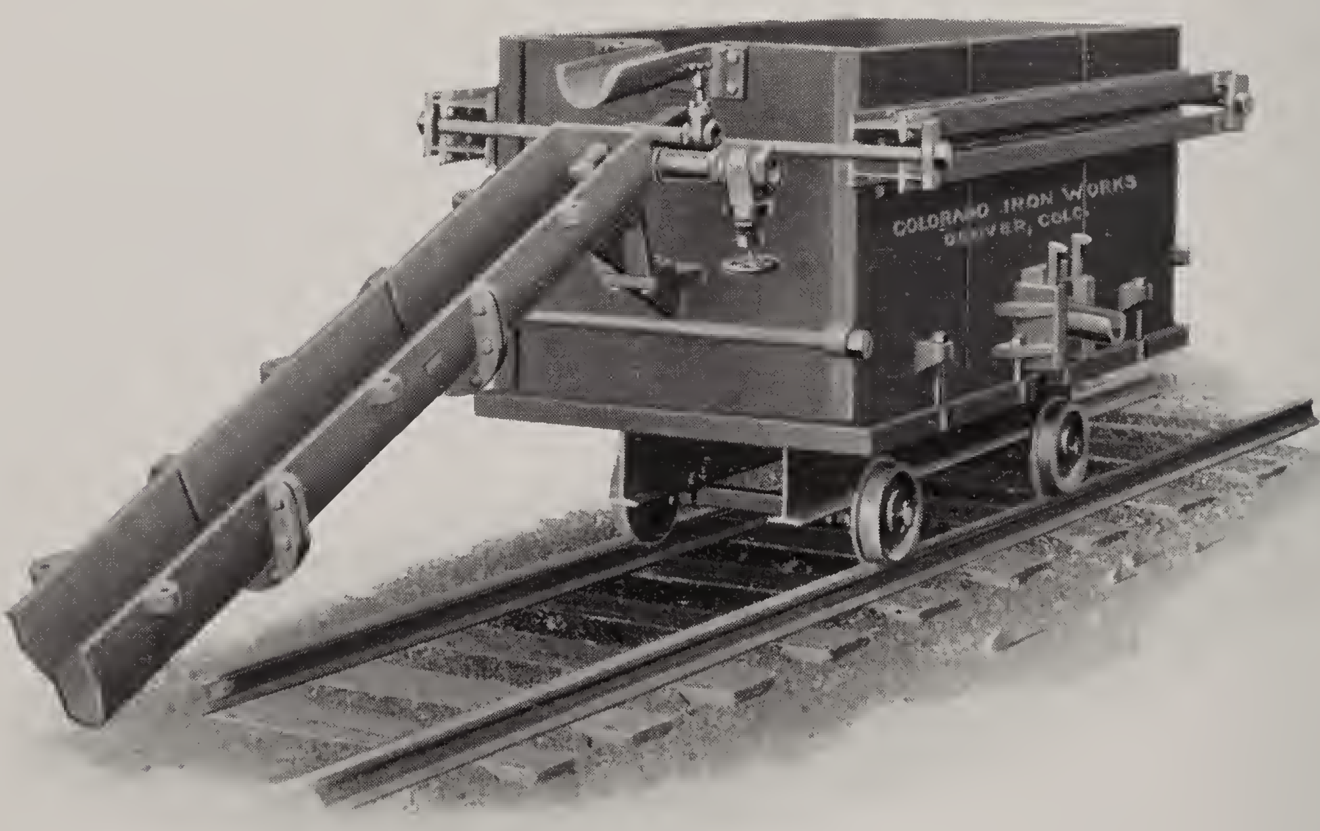


FIG. 99. 108″ x 48″ x 48″ PORTABLE FOREHEARTH OR SETTLER.

The forehearth shown in Fig. 99 is of our standard type, with side plates made in sections reinforced by I-beams owing to their considerable length. The matte tapping block is of cast iron with cooling pipe cast inside, held in position, together with the spout, by gib head steel wedges.

This illustration shows a slag granulating gutter attached to the end, below the overflow spout. It consists of a cast iron trough into the end of which the slag flows, being met by a stream of water under pressure issuing from the flattened nozzle shown in the illustration.

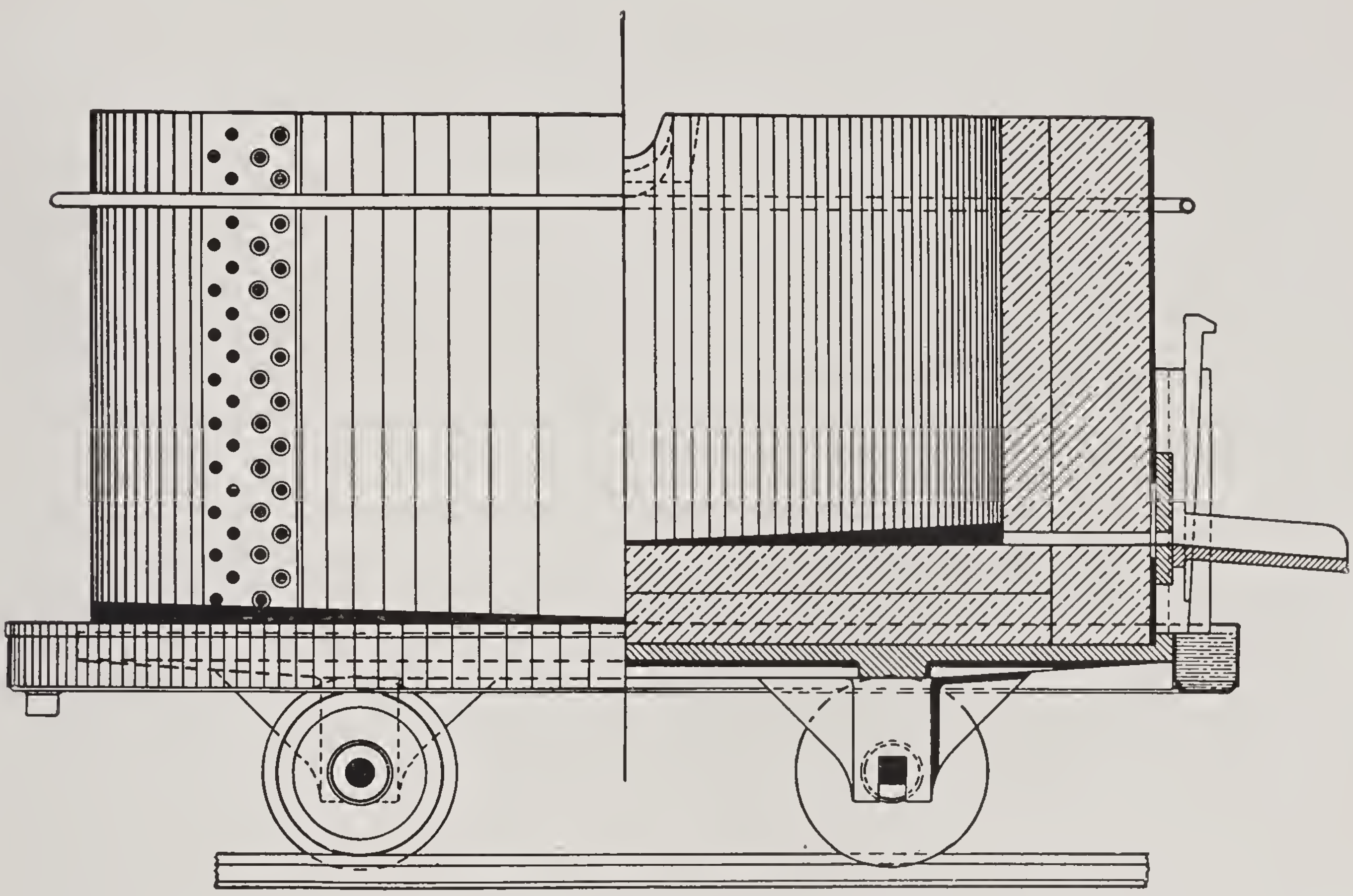


FIG. 100. ROUND PORTABLE FOREHEARTH OR SETTLER.

Beneath this nozzle is another opening, through which the overflow water from the jackets is discharged. The high pressure stream granulates the slag and the jacket water, which is in greater volume but at low pressure, serves to transport it. This is by far the cheapest method of slag disposal, but its use is limited to places where the slag dump is well below the level of the furnaces.

Some furnace men prefer round settlers. That shown in Fig. 100 is the same in all essential particulars as our round stationary forehearth, except that it is mounted on wheels to permit its removal for relining. It is shown with a waste water gutter at the bottom, to collect the cooling water flowing down the curb. We build forehearths of this type in all sizes from eight to fifteen feet diameter.

Stationary forehearths of the general type illustrated on this page are at present in more general use in plants of considerable size than the rectangular mounted ones. By reason of their large area the danger of mechanical loss of matte is reduced to a minimum, and a large storage capacity for the matte is secured, which is important in connection with converter plants.

The large volume favors separation although the contents chill at the points remote from the travel of the highly heated material

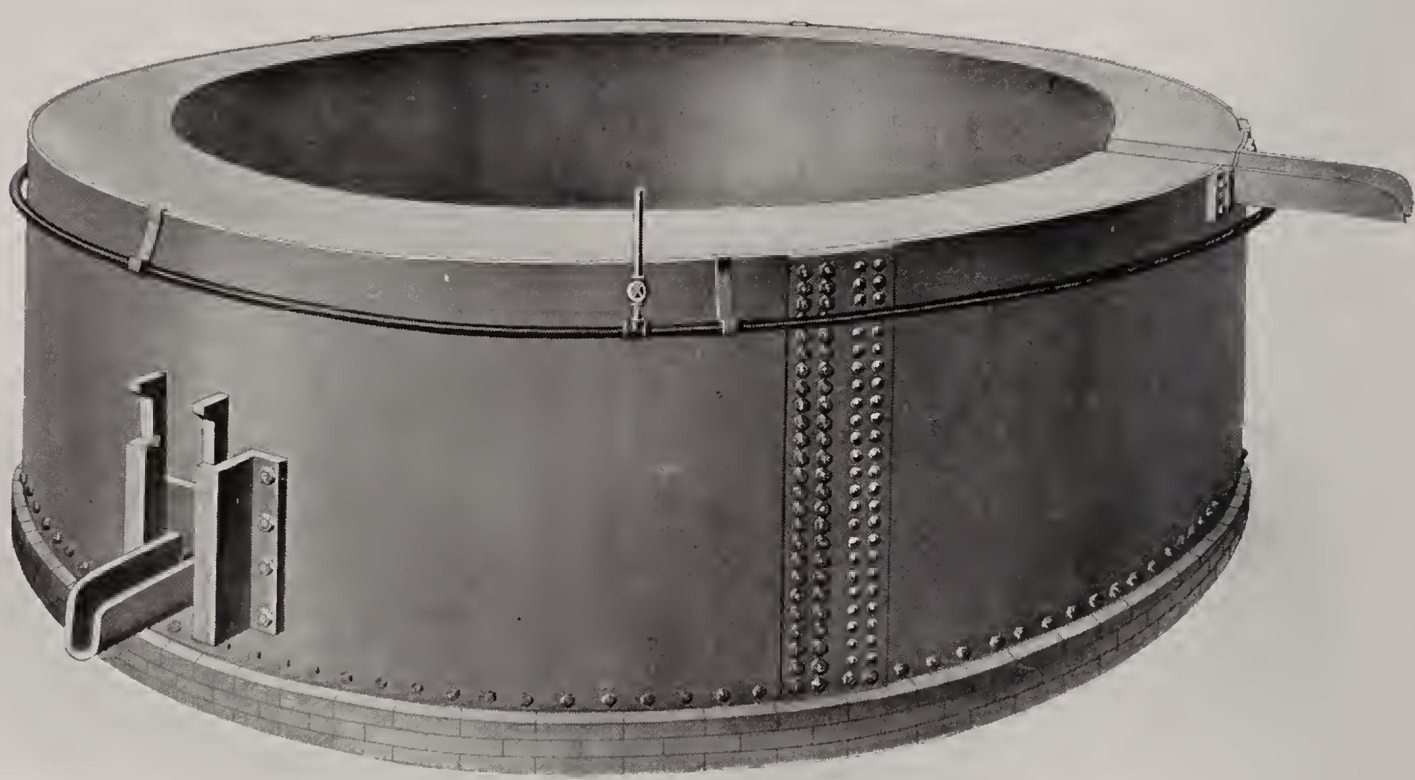


FIG. 101. STATIONARY FOREHEARTH OR SETTLER.

and, as in smaller forehearths, a crust forms which will support the weight of a man.

These forehearths are made of heavy steel plate, the form making it a simple matter to provide the necessary strength. They are lined with refractory brick, such as magnesite, and as the shell is cooled by a spray from a pipe encircling the curb near the top, there is but little trouble due to corrosion or burning out. These forehearths, when receiving a continuous stream of slag and matte of suitable volume, are kept in service for a very long time.

Usual sizes are eight, ten, twelve and fifteen feet diameter, with matte tapping block suited to the service required.

Matte Settling and Separating.

The engraving on this page illustrates an equipment for settling and separating matte from slag, which consists essentially of a series of settling pots with suitable pits in the ground to accommodate them with their tops at the general level of the surface, in order that they may be conveniently filled with fluid slag. After standing a sufficient length of time to allow the slag and matte to separate,

FIG. 102. MATTE SETTLING SYSTEM.

the pot is raised out of the pit, the slag tapped by a tap hole in the side of the pot, the matte tapped at the bottom, and finally the pot dumped to discharge the skull or shell of matte which has chilled all over the inner surface.

The equipment consists of an overhead tramway erected over a line of pits in connection with suitable traverse and hoisting machinery adapted for transferring the settling pots to any point along the line, lowering away into the pits when empty, hoisting them out when full and transferring them to a convenient point for tapping the slag into slag trucks for conveyance over the dump. After the slag is thus tapped from a settling pot the latter is transferred along the line to some convenient point where the matte is tapped

into suitable molds, from a tap hole near the bottom. The settling pot is then dumped by machinery at any convenient point on the line, depositing the shell of chilled matte on the ground. The pot is then hoisted away, transferred to a point over any pit and lowered into it to be filled again with fluid slag. And so with all the settling pots in the system.

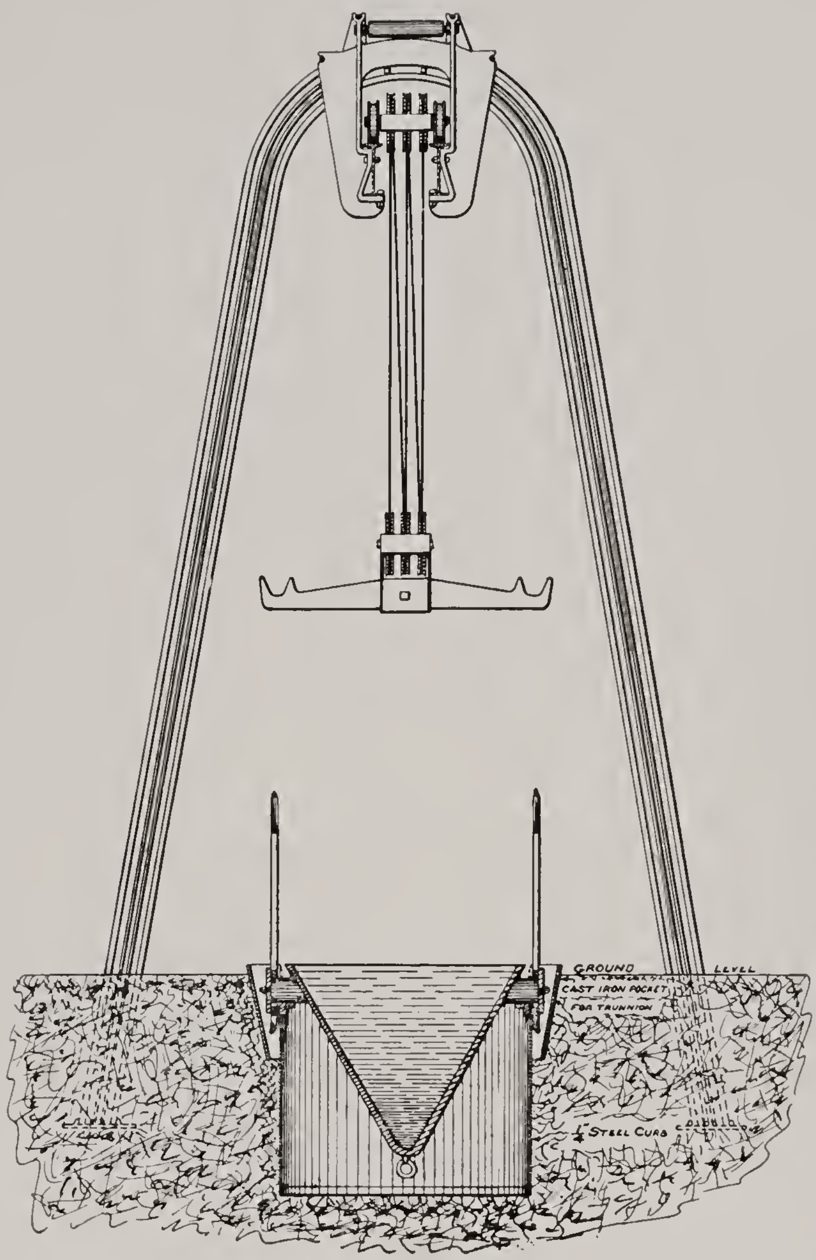


FIG. 103. TRANSVERSE SECTION THROUGH MATTE SETTLING SYSTEM.

The hoisting and traverse machinery and the overhead tramway with its equipment of trolleys, ropes, pulleys, sheaves, etc., are of a system such as we have had in successful use for some twenty-five years at our works for hoisting and transferring heavy machinery, and it is well adapted for the service of handling settling pots in such a system as that above described. The outline cut above shows some of the general features of the construction.

This matte settling and separating system was worked out and built by us for a large western lead smelter where it was in continual satisfactory operation for several years prior to the shutting down of the plant following its consolidation with others.

Slag Trucks.

The slag truck as made at the present time is the result of development by us in the endeavor to supply our customers with larger and more efficient slag disposal equipment necessitated by the constantly increasing capacity of their furnaces. The need of such a device was first felt when the slag dumps became large and the distance to which slag had to be hauled increased. At first the slag truck was small and simple, but it has now become equal to all demands as to capacity and ease of operation.

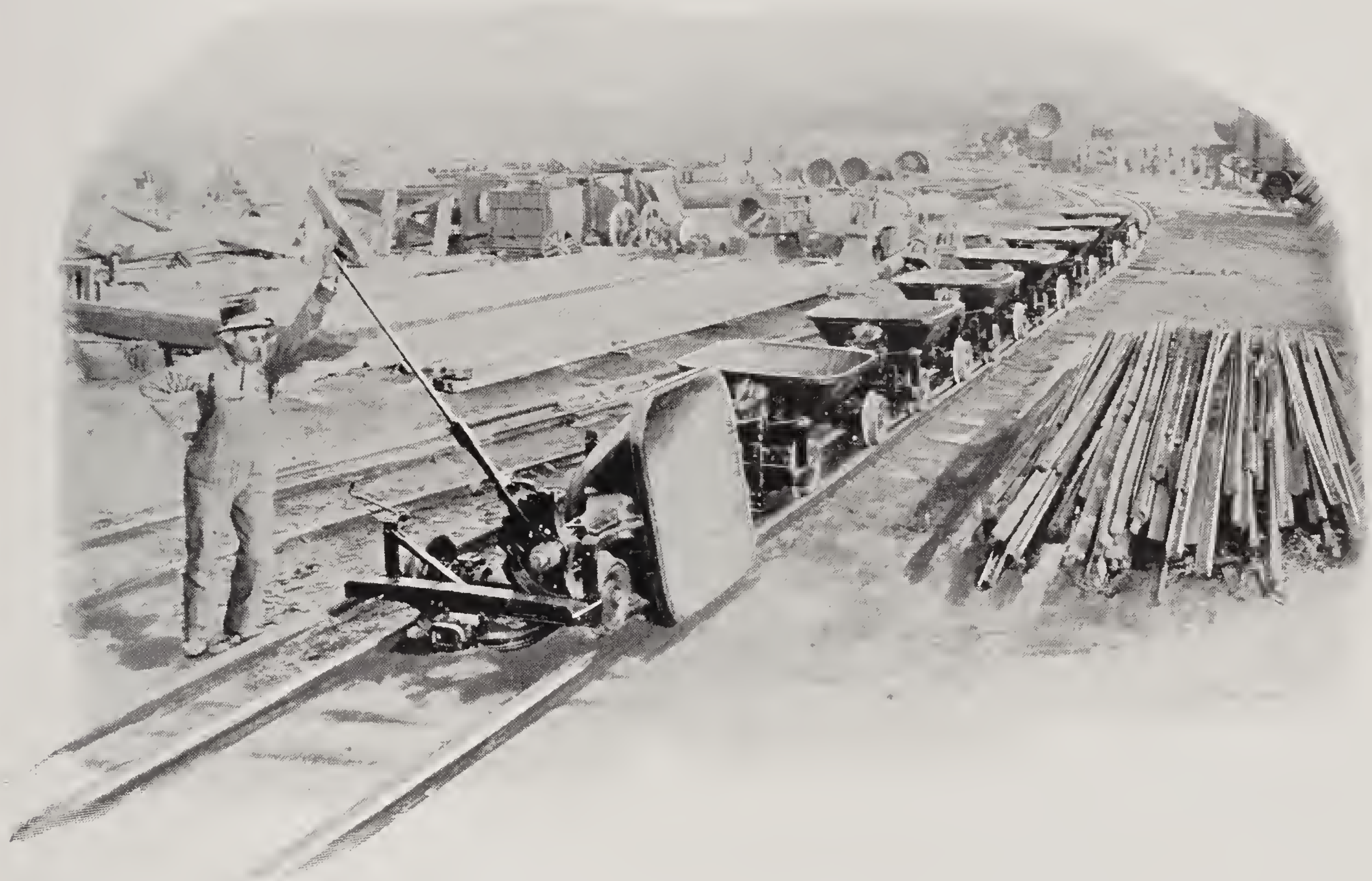


FIG. 104. LEVER DUMPING SLAG TRUCKS OF 12 CU. FT. CAPACITY.

The first great improvement was the rolling trunnion, originated by us, which causes the pot to dump well beyond the side of the track. To this have subsequently been added the screw dump feature, and finally, the Fitts patent worm release. Meanwhile we have studied our slag trucks in actual use and have ascertained wherein certain details could be improved. Having made good use of our exceptional facilities in this direction, we have found among other things the proper iron mixture and the best forms of bowls to withstand the severe duty imposed upon them.

Of the very great number of slag trucks we have built, we have selected a few for illustration on the following pages, which will serve to show the variations in size and design. They are of two general types, those dumped by a hand lever, and those operated by a screw in connection with a worm wheel on the trunnion. All are so balanced that they are top-heavy when full, but stable in the upright position and the dumping lever is thus necessary only as a means of controlling the side on which the pot is to dump. The screw dump cars, while having the bowls balanced in the same manner, permit them to be dumped slowly, as when it is desired to retain a shell in the bowl for resmelting. The righting of an ordinary screw dump bowl is slow, and to overcome this the Fitts patent

FIG. 105. SCREW DUMPING SLAG TRUCKS OF 45 CU. FT. CAPACITY.

worm release was devised. It is used for disconnecting the worm from the worm wheel, after the pot is dumped, to allow it to return to the upright position by gravity.

The dimensions noted in the descriptions on the following pages apply only to the particular trucks illustrated. The designs are susceptible of changes and may embody platforms and brakes at one or both ends. We shall be glad to furnish dimensions within which we can build trucks conforming to specified restrictions.

Our designs, having come into such general use, have been extensively copied, but our opportunities for observing the work of slag trucks at all the western smelters have enabled us to maintain our position in advance of all others in the manufacture of this class of equipment.

We build slag trucks in all sizes and believe we can meet all demands upon us in the future, as we have done in the past.

Lever Dump Slag Truck.

The engraving shown herewith represents one of a lot of sixteen slag trucks of nine cubic feet capacity, shipped to Mexico. They are designed to receive a single tapping of slag from lead blast furnaces.

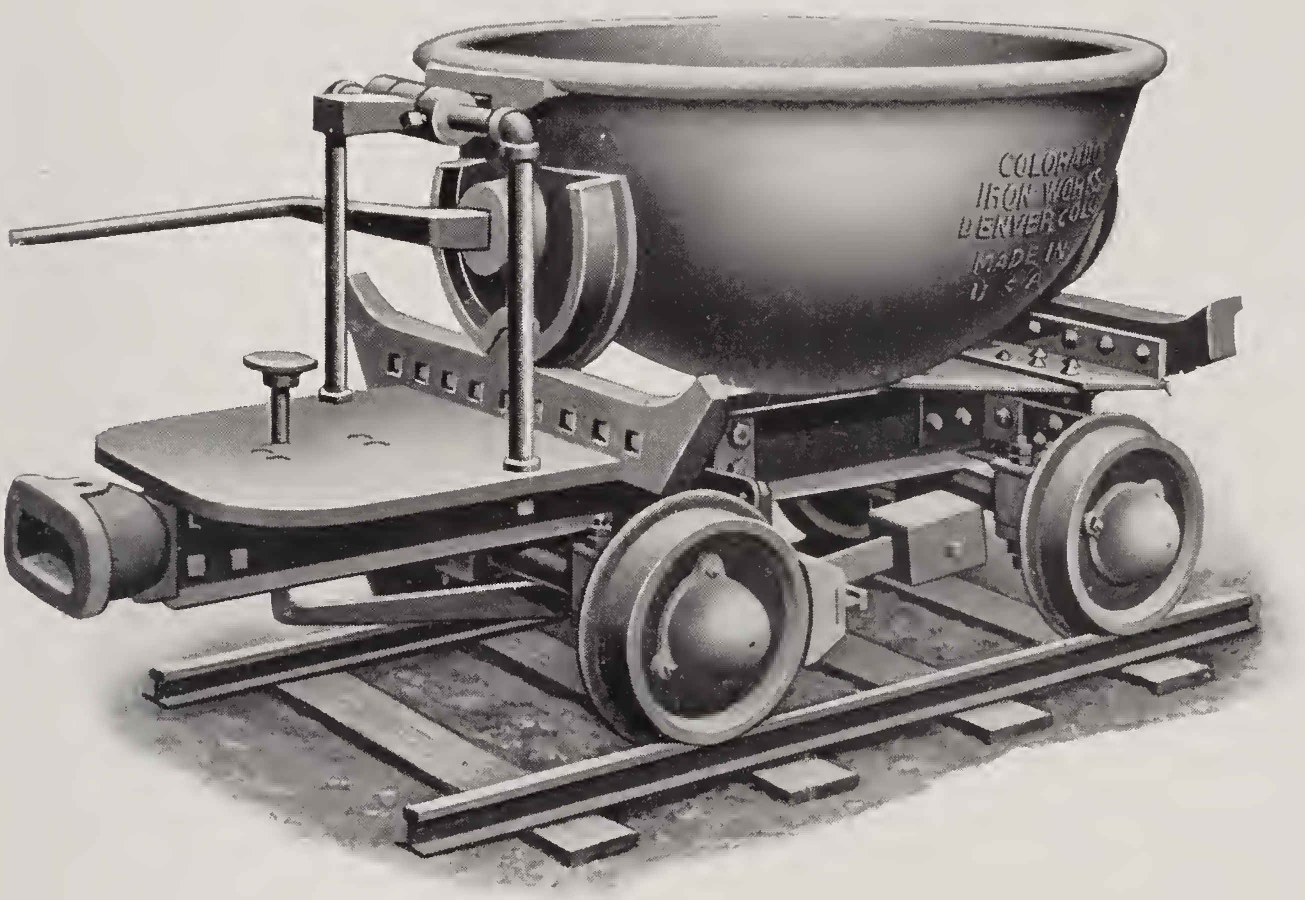


FIG. 106. 9 CU. FT. SINGLE BOWL LEVER DUMP SLAG TRUCK.

These trucks were built to run in trains, each, however, being controlled by foot brakes.

The bowl is hemispherical and is dumped by means of a hand lever at one end. The locking device shown retains the bowl in its upright position when filled with molten slag and in transit.

The entire height of truck from the top of the track rail to top of bowl is thirty-six inches, and gauge of track twenty-four inches.

Lever Dump Slag Truck.

The slag truck shown below is of a type of which we have built a large number. The bowl has a capacity of twelve cubic feet. The dumping is effected by a lever, the bowl returning to the upright position by gravity and being then held against tipping by hooks.

The Nesmith patent double bowl slag truck was originally devised to provide greater capacity than obtainable with a single round

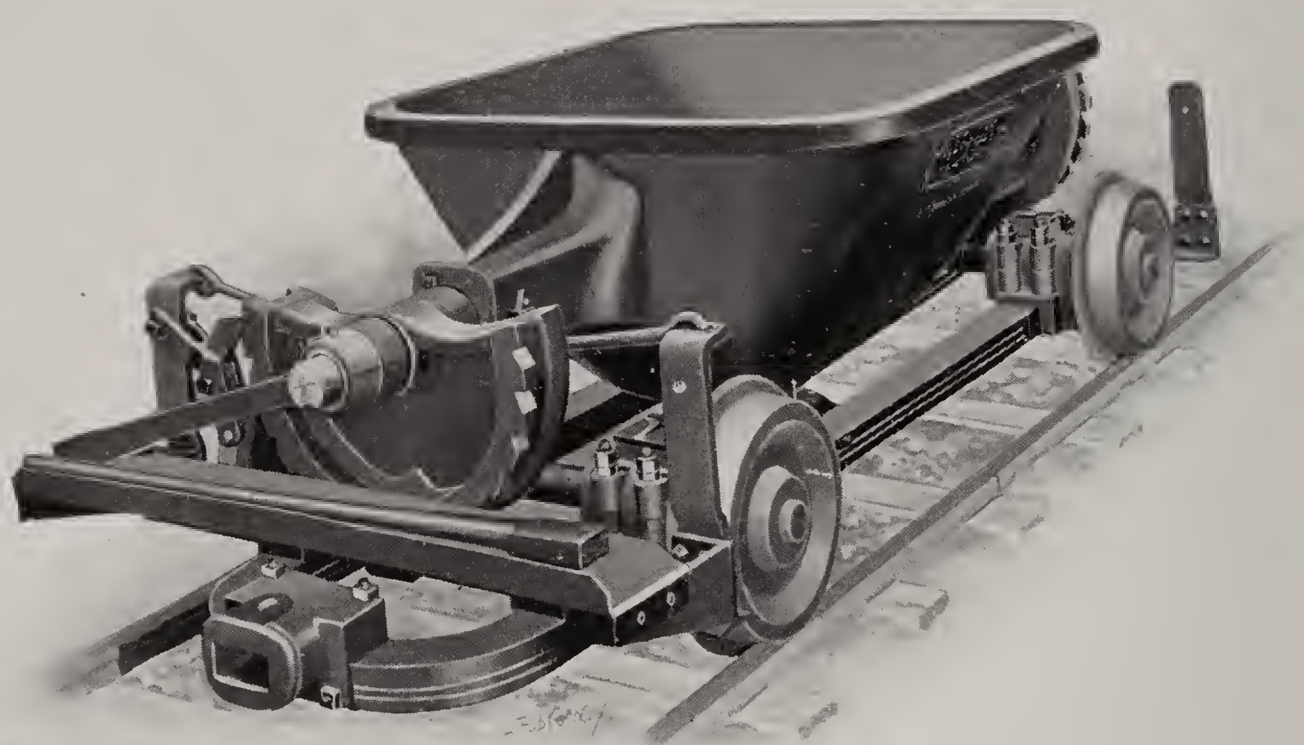


FIG. 107. 12 CU. FT. SINGLE BOWL LEVER DUMP SLAG TRUCK.

bowl, without increasing the height. Besides its use as the main equipment for slag disposal, it is also used at some plants having larger trucks, for the purpose of trimming the surface of the dump.

The bowls have each a capacity of 7.8 cubic feet, a total of 15.6 cubic feet for the truck. The bowls are carried by trunnions in a frame which swivels on a central pivot, thereby securing stability in haulage and the ability to exercise effective control in dumping. The design also permits of dumping the slag well beyond the track. The illustrations show the truck in position for haulage and with one bowl dumped. Hand brakes provide for control of speed in going down grade.

Lever Dump Slag Truck.

FIG. 108. 15.6 CU. FT. NESMITH PATENT DOUBLE BOWL SLAG TRUCK.

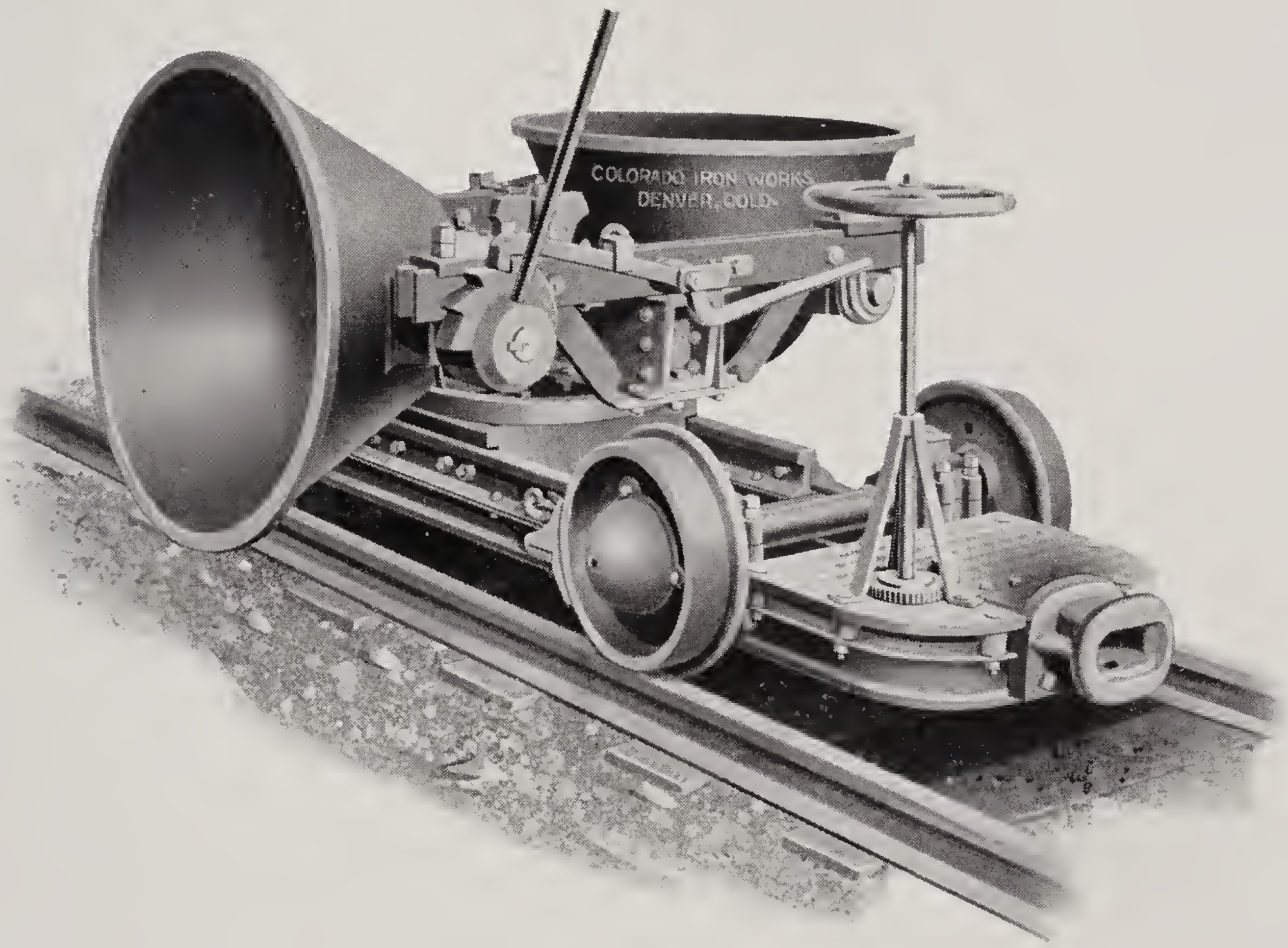


FIG. 109. 15.6 CU. FT. NESMITH PATENT DOUBLE BOWL SLAG TRUCK.

Lever Dump Slag Truck.

On this page we illustrate a large elliptical bowl lever dumping slag truck. It combines large capacity with small height, features which will enable many who desire to increase their tramming capacity to do so without incurring the expense of relaying tracks or lowering their tracks in the truck stations. The bowl is top-heavy when full and self-righting when empty.

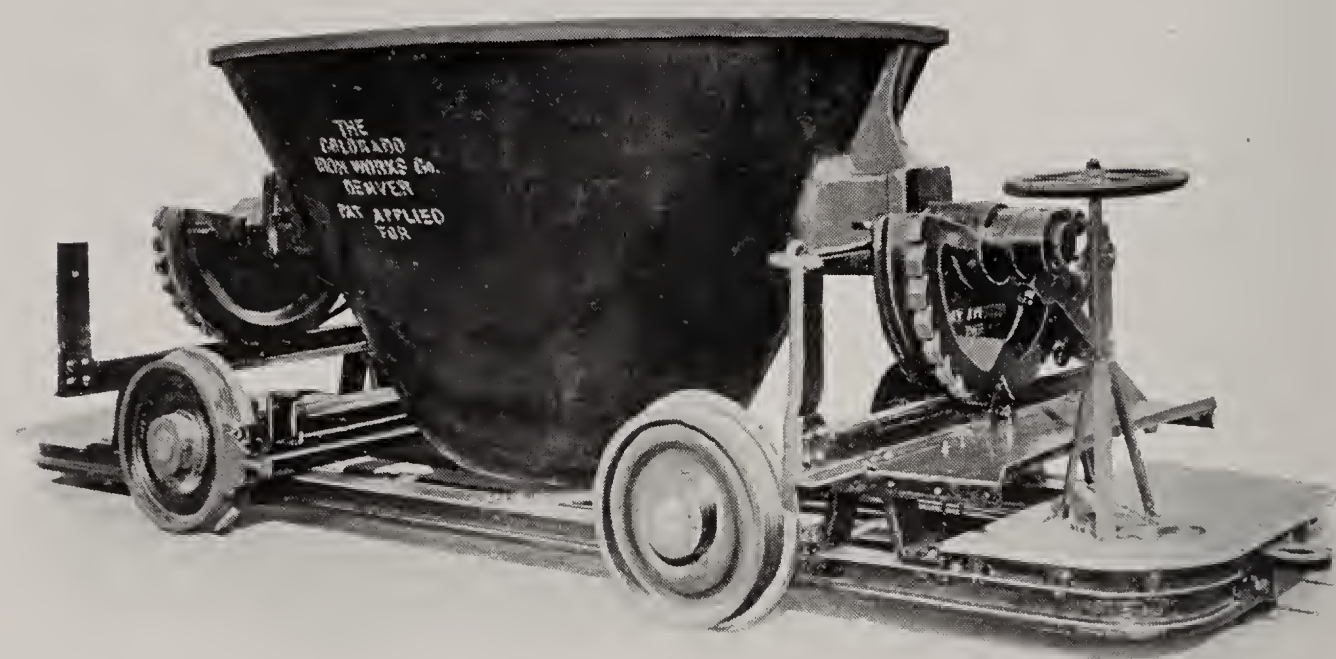


FIG. 110. 31.7 CU. FT. ELLIPTICAL BOWL SLAG TRUCK.

The total height from top of rail to top of bowl is three feet, seven and one-half inches, but little more than the Nesmith double bowl truck, and the overall length is fourteen feet, four inches. The overall length is subject to change, depending on whether a platform is placed at one or both ends.

An examination of the illustration will show that there is no superfluous height. By careful study we have worked out designs for our large slag trucks in which the running gear adds the least possible amount to the actual height of the bowl, thus providing the maximum capacity with the minimum height.

Lever Dump Slag Truck.

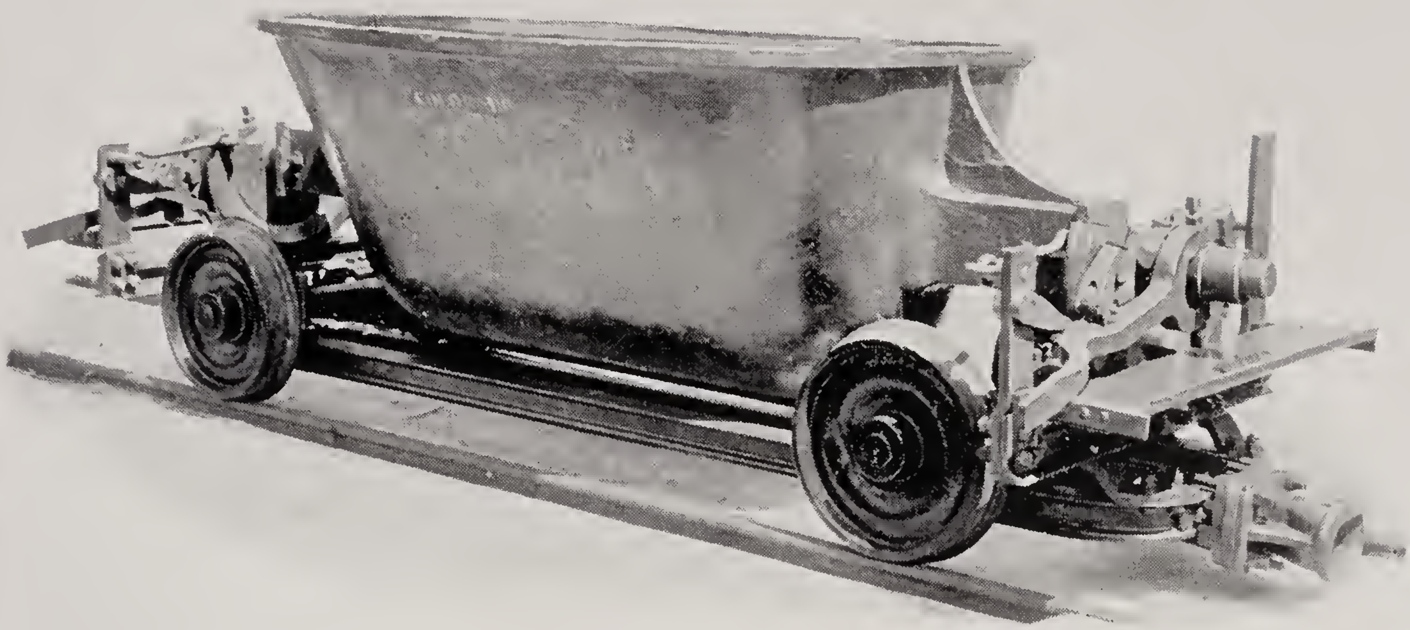


FIG. 111. 44 CU. FT. SEMI-ELLIPTICAL BOWL SLAG TRUCK.

The two engravings on this page show our 44 cubic foot capacity semi-elliptical bowl slag truck, which operates and is built on precisely the same principle as the 31 cubic foot elliptical bowl truck just described. We furnish these with or without platforms at one or both ends, and with brakes, or simply with draw heads and draw bars when the trucks are handled in trains. The height from top of track rail to top of bowl is 44 inches. Approximate shipping weight 8,500 pounds.

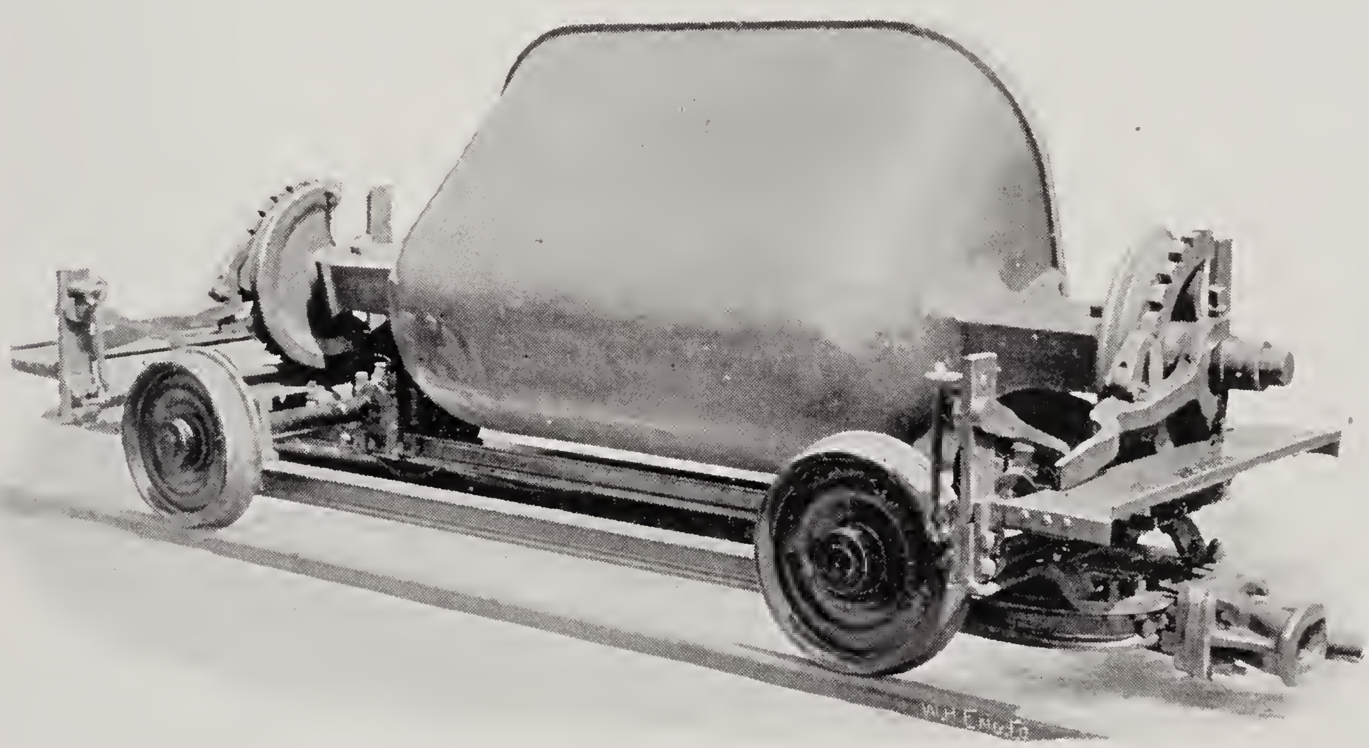


FIG. 112. 44 CU. FT. SEMI-ELLIPTICAL BOWL SLAG TRUCK.

Screw Dump Slag Truck.

The illustration on this page shows a screw dump slag truck with a round bowl of 25 cubic feet capacity, and with platform and hand brake at one end. In this construction the bowl is carried in a heavy steel band, the trunnions being attached to the band, this device facilitating renewal of the bowl.

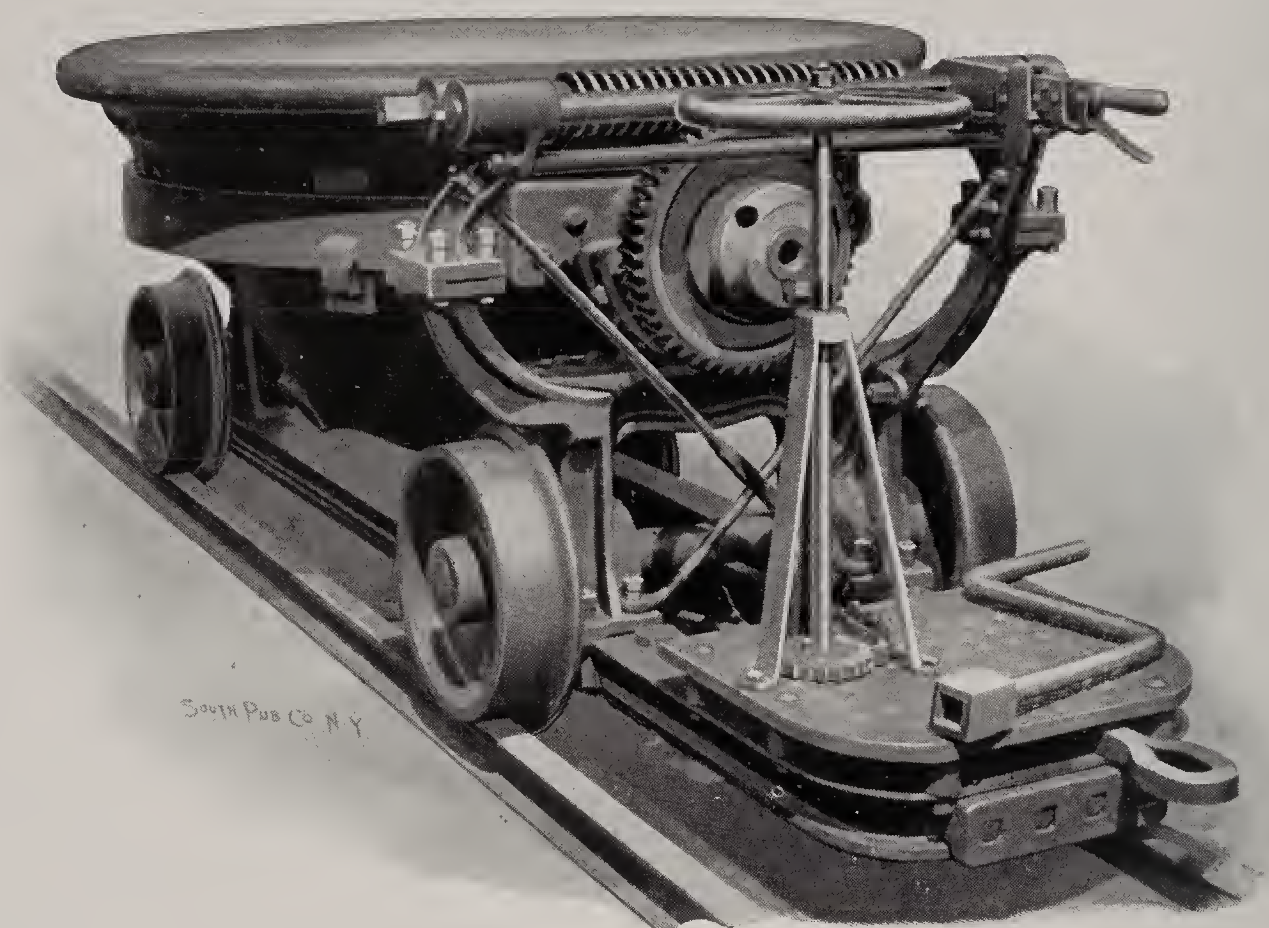


FIG. 113. 25 CU. FT. SCREW DUMP SLAG TRUCK.

The truck shown has the Fitts patent worm release mechanism, but customers can exercise their preference as to this and other features as we can and do furnish our slag trucks with any combination of details desired.

In a slag truck of 25 cubic feet capacity, there is no great difficulty in keeping down the height. In this one a height from top of rail to top of bowl of three feet, three inches is secured with a round bowl five feet, six inches outside diameter, this being also the extreme width of the truck. The overall length, with platform at one end as shown, is eleven feet, one inch.

Screw Dump Slag Truck.

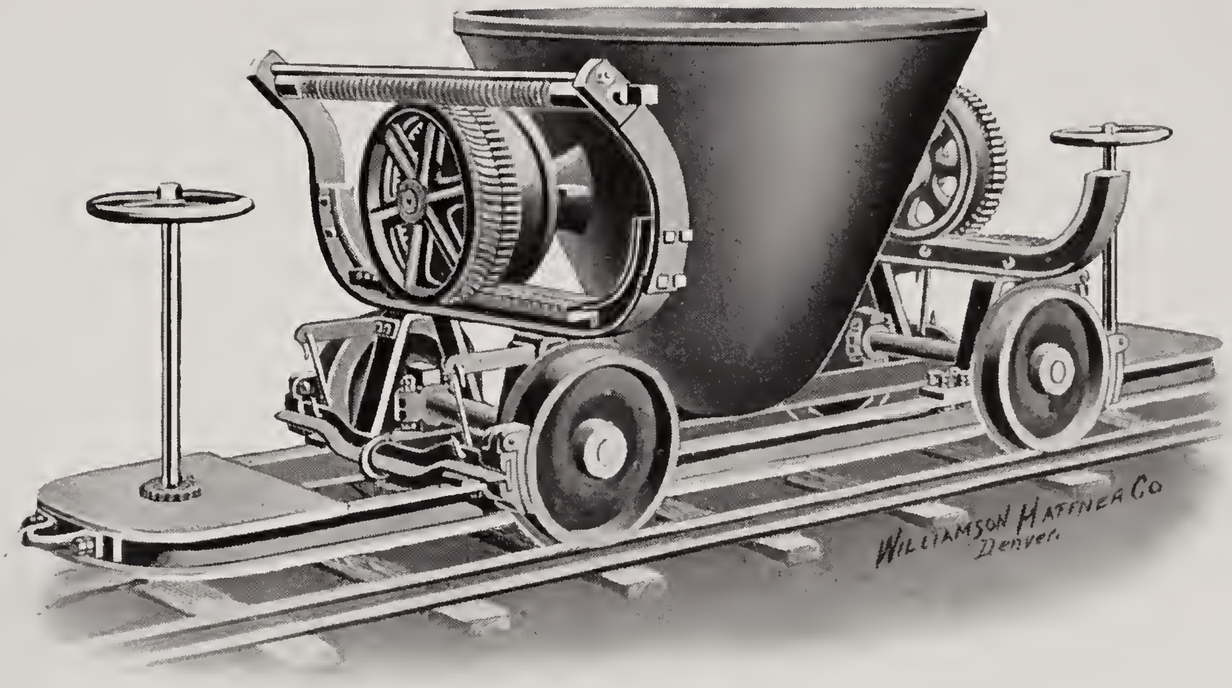


FIG. 114. 35 CU. FT. ROUND BOWL SCREW DUMP SLAG TRUCK.

The slag truck shown on this page measures four feet, seven inches from top of rail to top of bowl, has an extreme width of six feet and an overall length, with platform on each end, of thirteen feet, six inches.

The construction of the screw dump mechanism is well shown in the illustration. The bowl is carried on wheels fixed to the trunnions, these wheels roll on the rails at the ends of the truck frame. Adjacent to the rail is a rack engaging a gear carried by the trunnion, these parts assuring the return of the bowl to the central position. Placed next the gear is a worm wheel, which, with the transverse screw or worm, serves to control the dumping of slag.

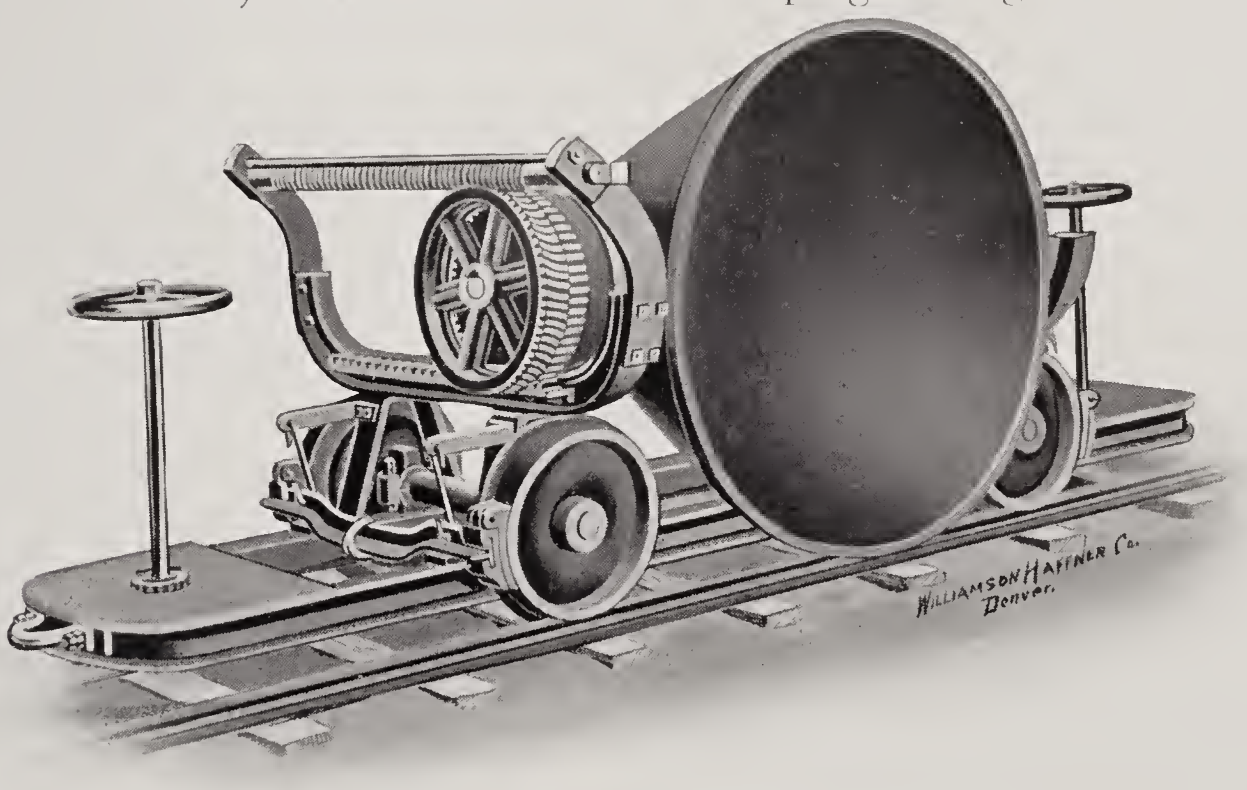


FIG. 115. 35 CU. FT. ROUND BOWL SCREW DUMP SLAG TRUCK.

Screw Dump Slag Truck.

The slag truck illustrated on this page is similar to the one just described, except that the bowl is carried in a trunnion ring instead of on trunnions forming part of the bowl casting, and that it is equipped with the Fitts patent worm releasing attachment. In other respects the two trucks are similar, and of the same dimensions, very nearly.

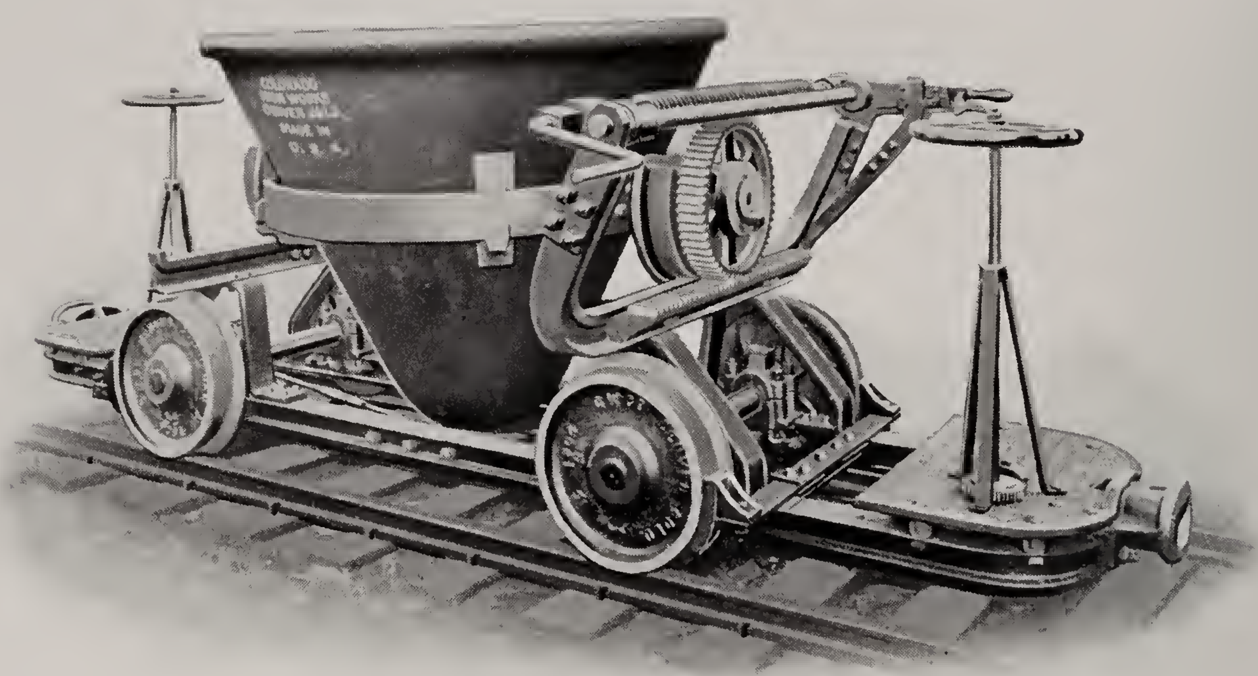


FIG. 116. 35 CU. FT. ROUND BOWL SCREW DUMP SLAG TRUCK.

A comparison of this slag truck with the one on the preceding page will serve to illustrate the difference between the ordinary screw dump and the screw dump with the Fitts patent worm releasing device. With the former, to return the bowl to the upright position after dumping, the screw must be turned, while in the latter the movement of the lever shown just above the brake hand wheel disengages the screw from the worm wheel, and the pot automatically rights itself by gravity. The worm, instead of being journaled in the yoke, is journaled in blocks keyed to a shaft which takes the place of the screw or worm in the simpler construction, and the hand lever being also keyed to this shaft serves to move it into and out of engagement with the worm wheel.

In the construction shown above, the separate gear is dispensed with and the rack, now made with diagonal teeth, engages the lower side of the worm wheel.

Screw Dump Slag Truck.

This slag truck has an elliptical bowl of 45 cubic feet capacity and is equipped with the most improved conveniences. The arrangement of the platform and brakes, such as we place on one or both ends of our slag trucks, is well shown in the illustration, and the construction of the Fitts patent worm release mechanism is also clearly brought out.

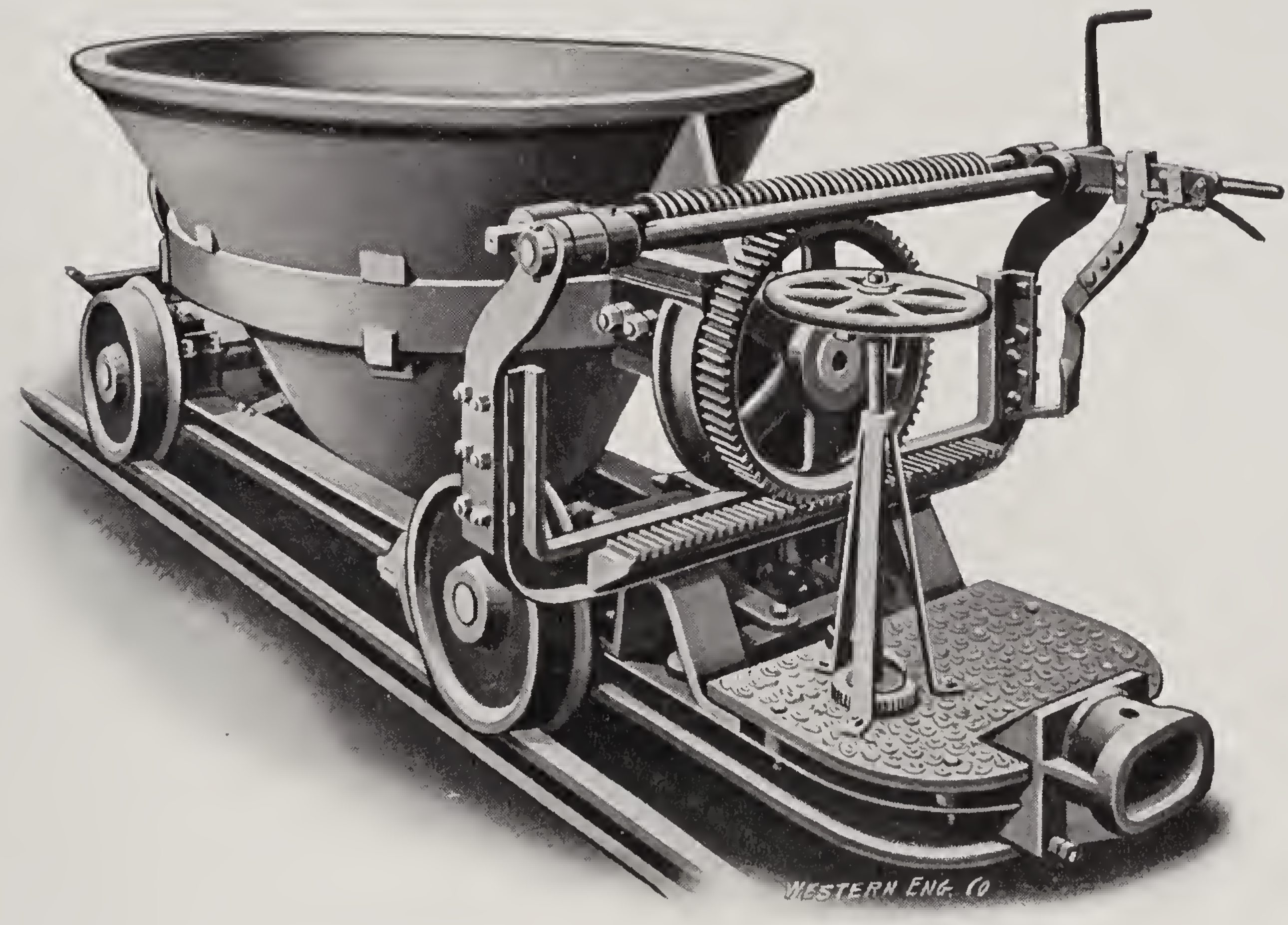


FIG. 117. 45 CU. FT. ELLIPTICAL BOWL SCREW DUMP SLAG TRUCK.

The bowl is dumped by operation of the crank attached to the end of the worm, but in righting the pot it is not necessary to reverse this operation, as is the case with the ordinary screw dump mechanism, but the depression of the latch lever disengages the worm from the worm wheel and the pot returns to the upright position automatically, the center of gravity being below the center of support when the pot is empty.

The manner in which the bowl is carried in the trunnion ring can be clearly seen in the illustration. The weight of the bowl is carried by brackets on the ends and seats on the sides, and the bowl is held in place by dogs fitted to square holes, the dogs being held in turn by keys. The height of this truck from top of rail to top of bowl is fifty inches.

Screw Dump Slag Truck.

The slag truck here shown is quite similar to the 44 cubic foot truck already described but is equipped with a screw dumping instead of a lever dumping mechanism. The general dimensions are similar, but intending purchasers should, of course, obtain exact dimensions from us if there is limited room. Mention of this is made because the particular slag truck illustrated here is not built so low as it could be should necessity require it, nor so low as the truck shown on page 131 and referred to above.

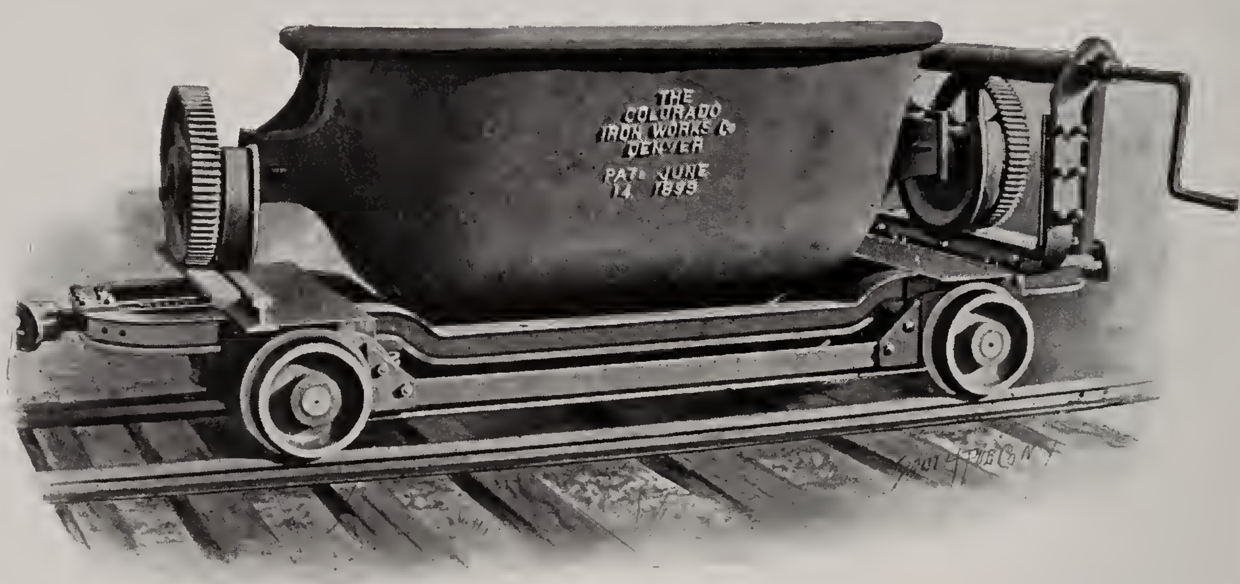


FIG. 118. 44 CU. FT. SEMI-ELLIPTICAL BOWL SCREW DUMP SLAG TRUCK.

The semi-elliptical form of the bowl shown in the illustration on this page enables large capacities to be obtained, at the same time keeping the overall height as small as possible, and we have built trucks of this form having sixty cubic feet capacity.

The car shown is without platform or brakes, but any requirements in this respect, as well as in other details, can easily be met. The flanged wheels which roll on the transverse rails take the entire weight of the bowl and a gear with rack having diagonal teeth serves to bring the bowl back over the center of the truck when in the upright position. The angle of the teeth of the gears is the same as the angle of the thread of the worm, so that the gear which engages the worm can be cut to fit the latter. Although shown without it, the Fitts patent worm release can be supplied, if desired.

Hand Slag Carts.

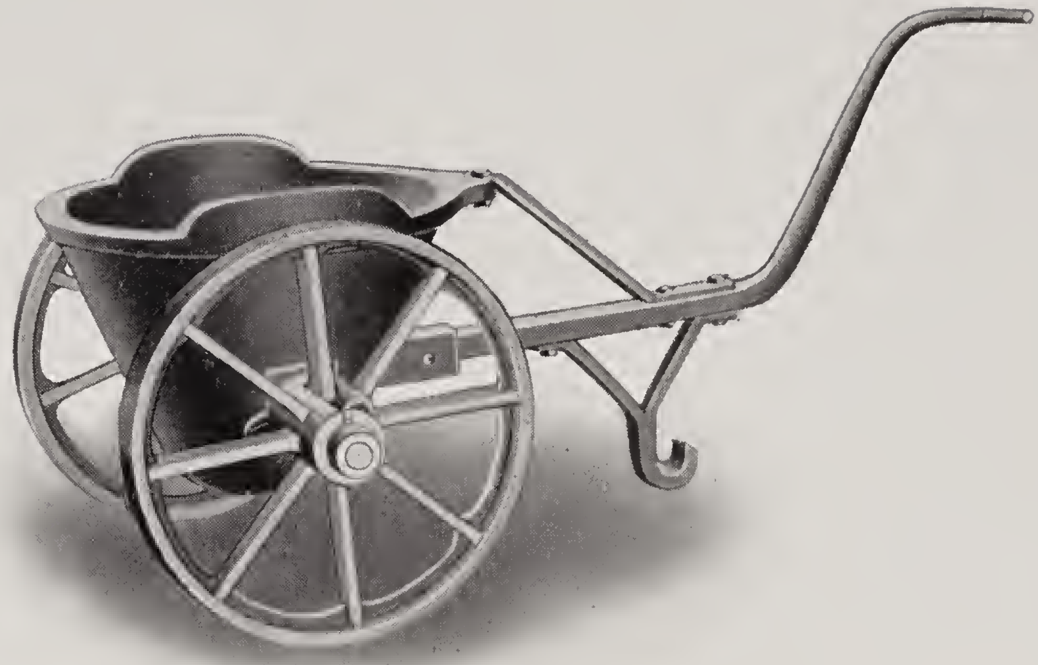


FIG. 119. STANDARD HAND SLAG CART.

The above illustration shows the general style of the standard hand slag cart used at many smelters. We make them with many sizes and styles of bowls, with or without roller bearings, the wheels and forged parts varying in size to suit the pot. A number of our bowls are shown in section on the following page. They are made of the same mixture as our cast iron jackets, which we have found very superior to resist sudden and repeated temperature changes.

Below is shown a special slag cart having a separable bowl with feet to hold it in the upright position. We have made them at times where it was desired to allow the slag to settle and solidify in the pot, but they can only be used on a relatively level floor, and the dead weight added by this construction is considerable. It should be noted that this pot cannot be dumped in the ordinary way.

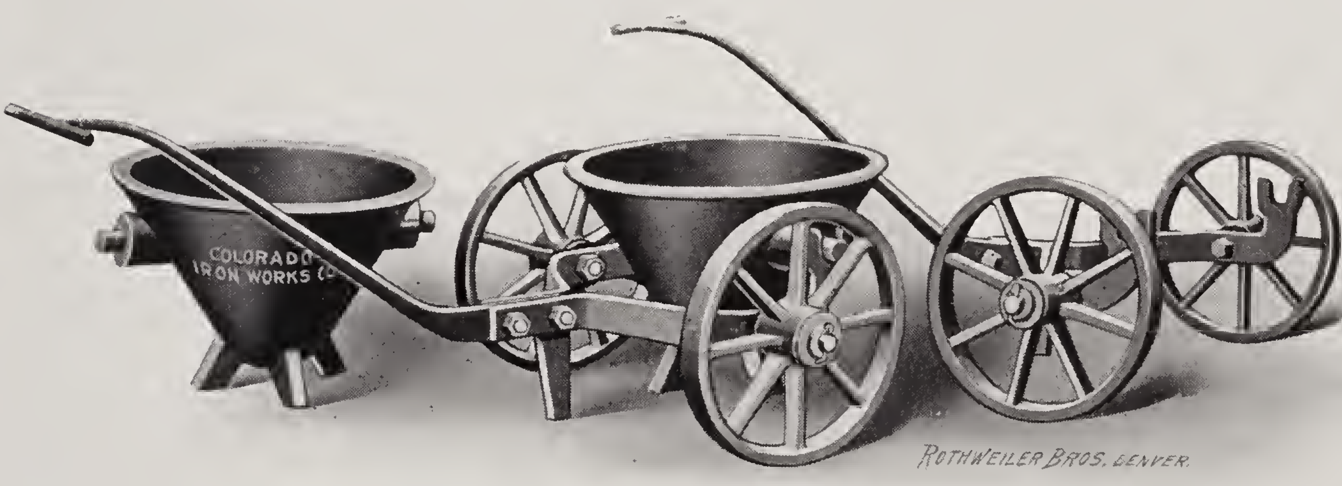


FIG. 120. SPECIAL HAND SLAG CART WITH SEPARABLE BOWL.

Hand Slag Cart Bowls.

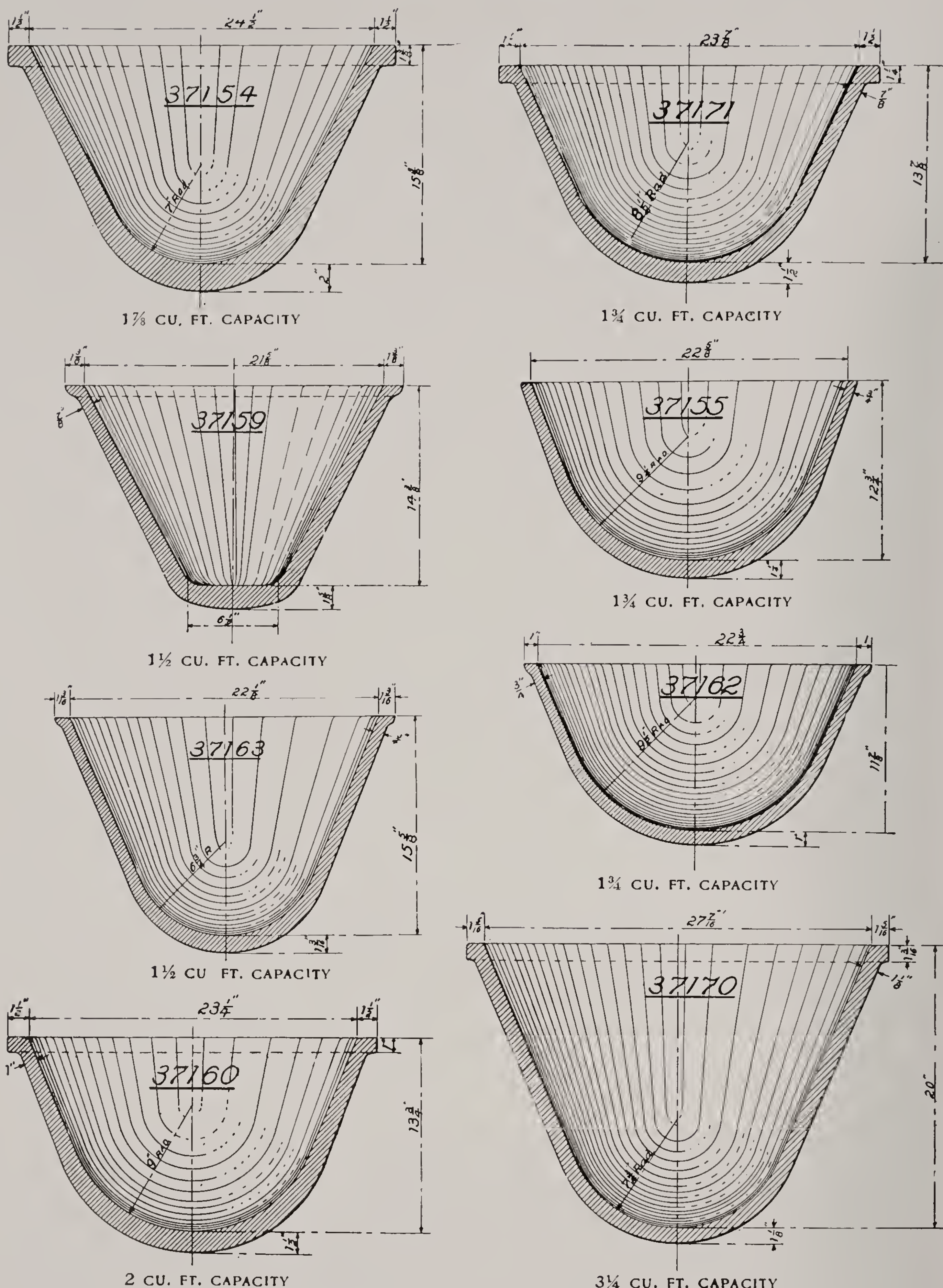


FIG 121. DIMENSIONS AND CAPACITIES OF SLAG BOWLS.

Matte Settling Pots.

The illustration on this page is of a mounted matte settling pot. We make them of our special water jacket mixture of cast iron, of 6 1-3, 7½ and 8½ cubic feet capacity. They are furnished with or without roller bearings and are ironed up like an ordinary hand slag cart.

They are used at lead smelters where the matte fall is light, being placed under the slag spout of the blast furnace, the matte settling to the bottom and the slag overflowing into the ordinary hand slag carts. They are arranged so that the spout can be placed on either side, a patch being furnished for the notch not in use.

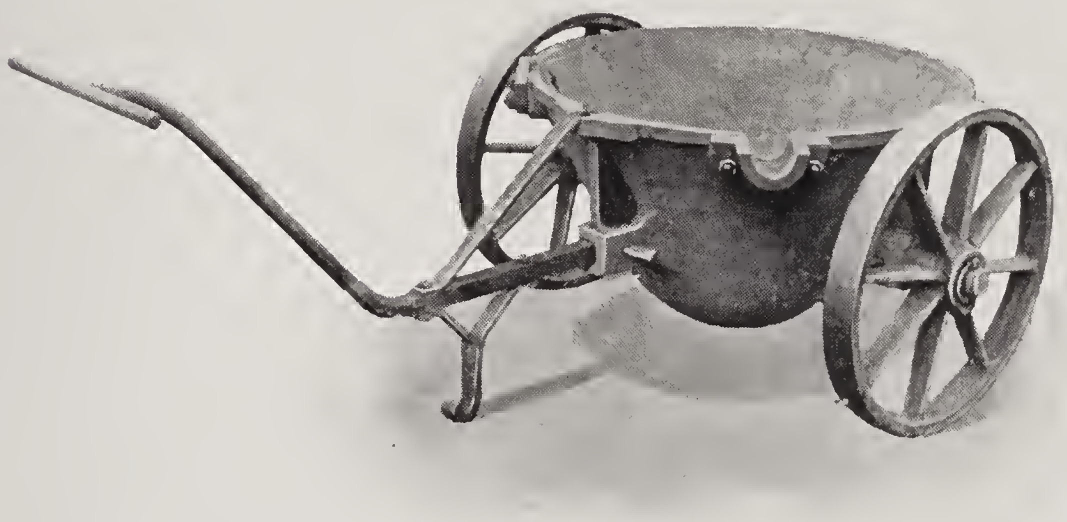


FIG. 122. MOUNTED MATTE SETTLING POT.

The principle underlying their use is the same as that of the forehearth or settler, but their form is more convenient and portable. In operation, one of these matte pots is kept in service until practically full, when it is removed and the matte allowed to cool in it, its place being taken by another similar pot. When the matte has solidified it is removed from the pot and conveyed to the furnace feed floor for resmelting, or crushed for roasting prior to resmelting.

A forehearth is of course a necessary adjunct to every large lead blast furnace, and to every furnace where the matte fall is heavy, but under the conditions stated, these matte pots are very serviceable and they are indeed sometimes used in connection with a forehearth, between it and the hand slag carts to act as additional means for preventing loss of matte.

The duty on matte settling pots being usually very severe, we have supplied many having vertical ribs radiating from the center at the bottom to a horizontal rib encircling the upper edge, as shown below. These have proved very satisfactory, the life of the bowl being materially increased over that of the ordinary unribbed bowl.

FIG. 123. MOUNTED MATTE SETTLING POT WITH RIBBED BOWL.

The illustration below shows a mould for either matte or black copper. The bowls are made of the best grade of cast iron, very heavy, and are mounted on wheels after the manner of a hand slag cart. We also have patterns for shallow matte moulds with flat bottoms, to facilitate breaking up the matte for sacking or crushing.

We have a large and varied assortment of patterns for lead bullion, copper and copper matte moulds. They are usually lettered with the name of the company in the bottom.

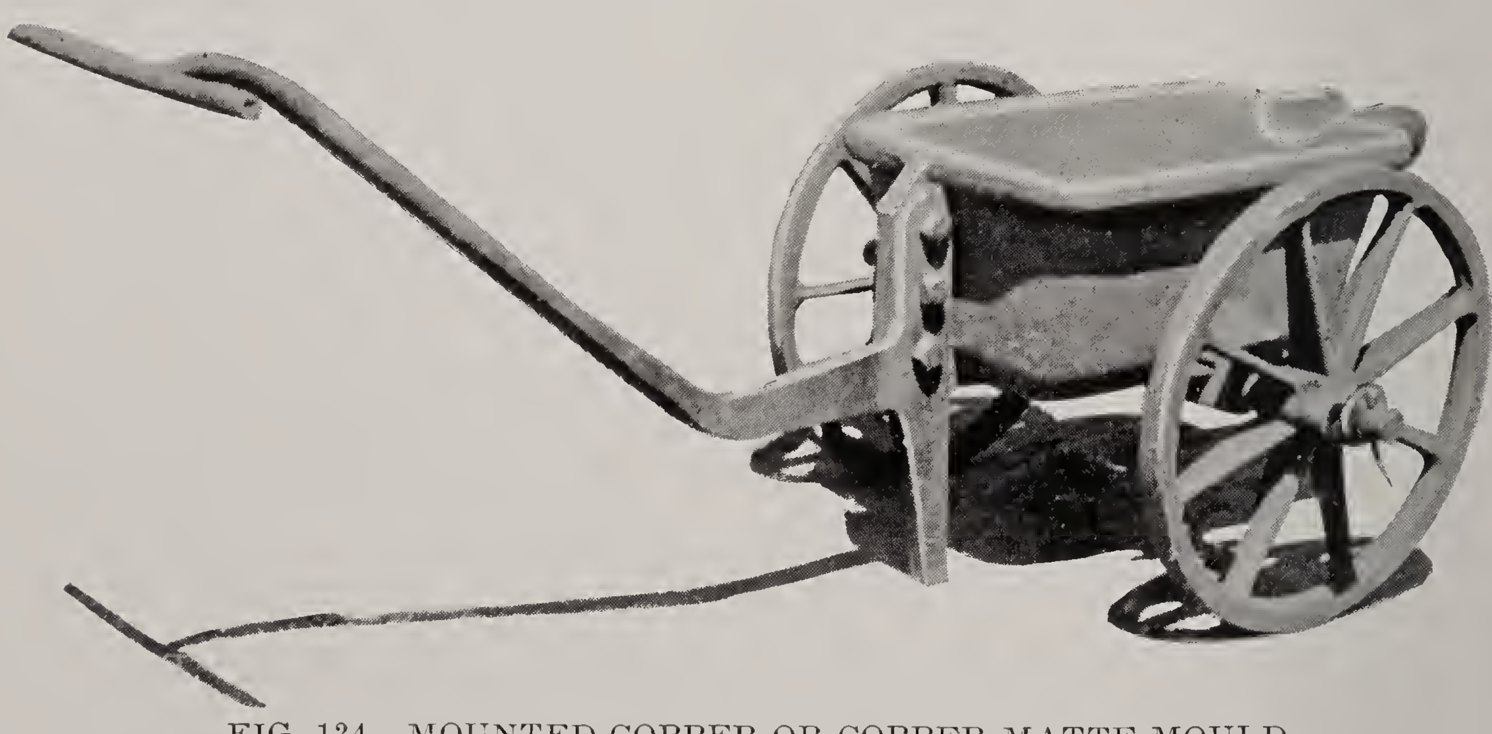


FIG. 124. MOUNTED COPPER OR COPPER MATTE MOULD.

We show in the engraving below our mounted ribbed matte mould. We have had the advantage of much experience in the use of properly designed moulds for copper matte, and while we have many patterns of different forms, we have found the one illustrated to be very satisfactory and in favor with furnacemen. A plain hand slag cart is used but the bowl is thoroughly ribbed on the outside as the cut shows.

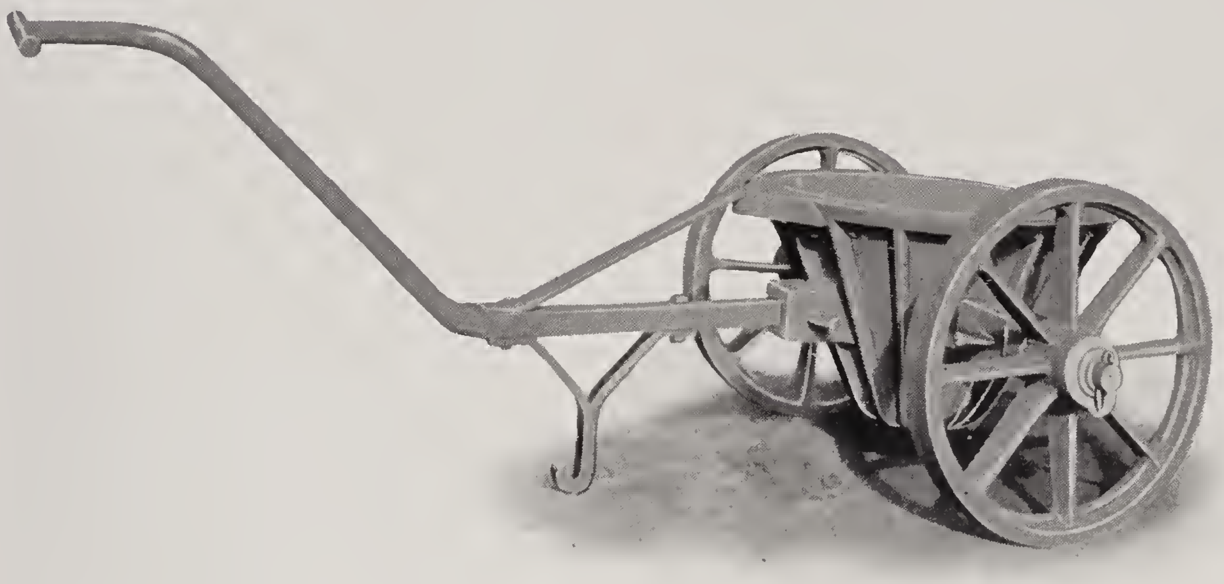


FIG. 125. MOUNTED MATTE MOULD.

We also show on this page a stationary matte pan, the end of which is placed under the matte tap of the forehearth. It is made of the best grade of cast iron, very heavy, and in sections, so that any desired length can be made up. The form is shallow, and the matte consequently cools rapidly and is easy to break up. Transverse ribs at the joints between the sections prevent the matte from running into a following section until the preceding one is partially filled.

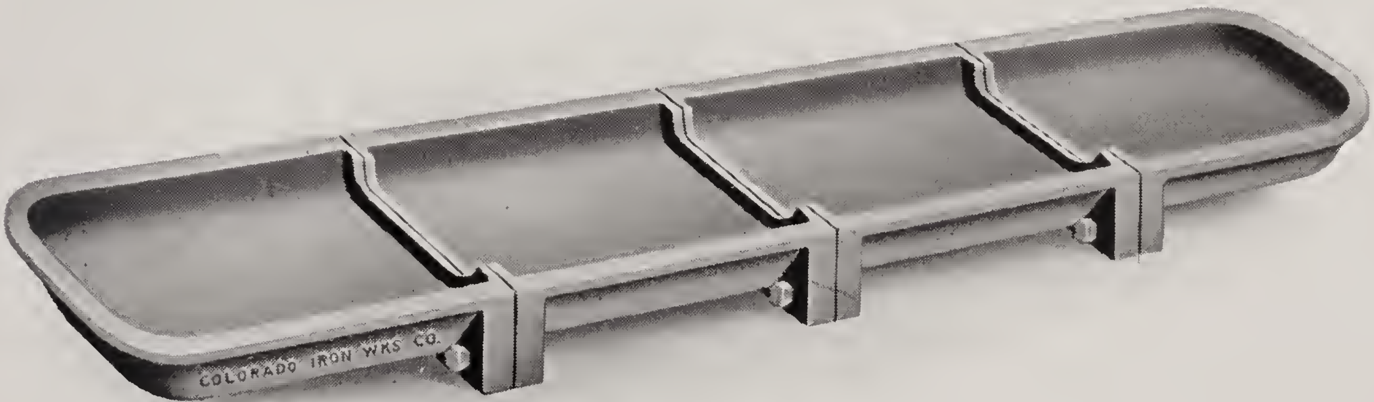


FIG. 126. SECTIONAL STATIONARY MATTE PAN.

Ore Cars.

Cars are largely used in and about smelting plants, and while we manufacture some thirty or forty styles and have excellent facilities for this class of work, we show only a few favored designs.

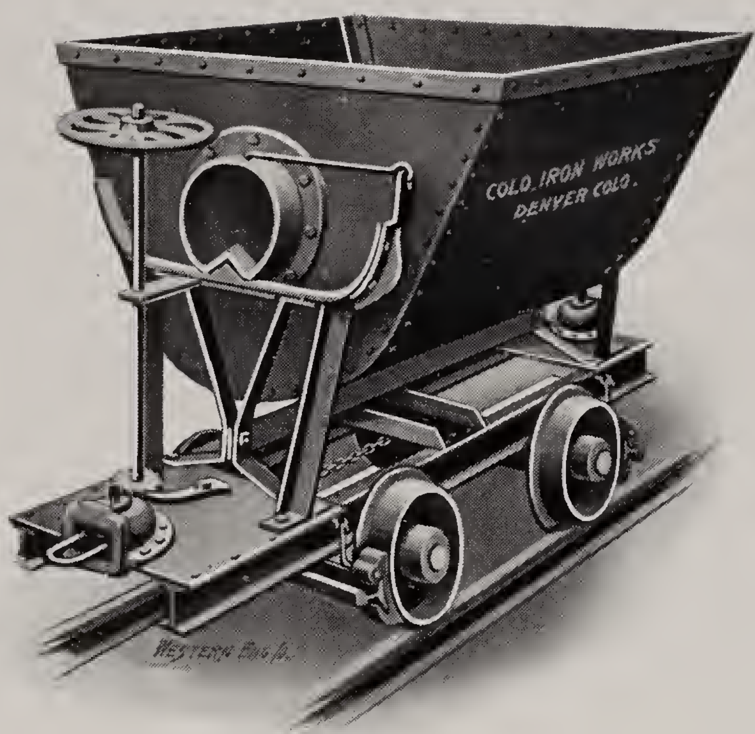


FIG. 127. ROLL SIDE DUMP CAR.

The roll side dump car shown in the annexed illustration is very convenient in many situations and we build it in large numbers. The center of gravity is above the point of support when full and below it when empty, so that it is easily dumped, and when empty, self righting. As shown, it has hand brakes and is arranged to be handled in a train, but its construction in these respects can be varied to suit the special purpose it is intended to serve. It is a very convenient form for charging blast furnaces and is made of from 20 to 100 cubic feet capacity; gauge of track 24 to 48 inches.

We show herewith another car for carrying ore, flux and fuel, which also dumps to the side. The side of this car is hinged at the top and fastened with a latch at the bottom, so that by raising the latch the contents of the car slides out by reason of the bottom being inclined. We make these cars of any desired size, and to dump on one or both sides. The one illustrated is a single side dump.

FIG. 128. SIDE DUMP CAR.

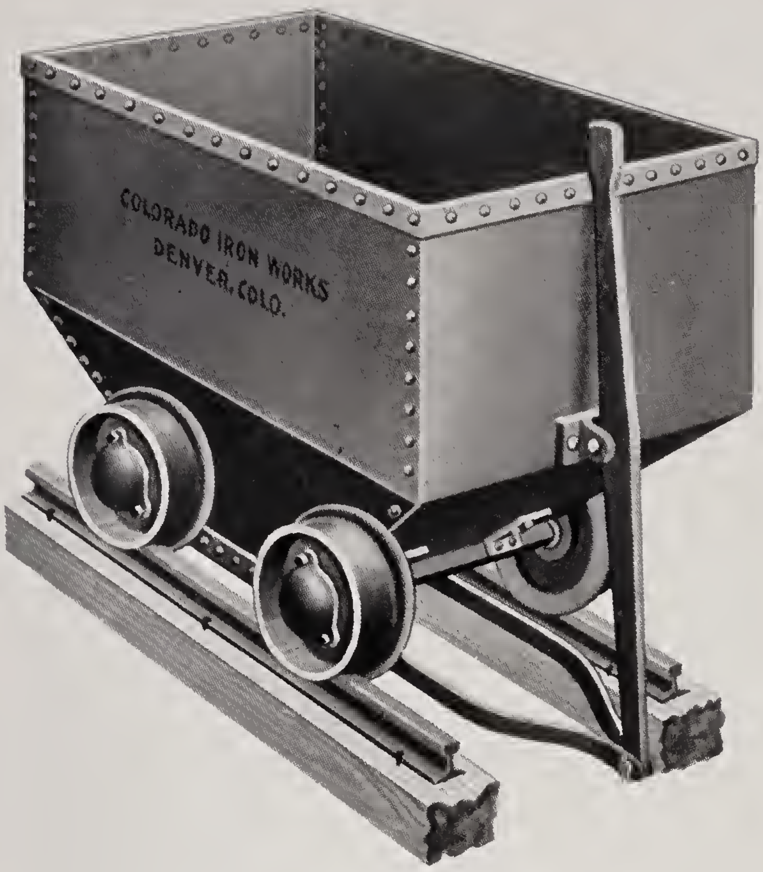


FIG. 129. BOTTOM DUMP CAR.

The annexed illustration shows a car which dumps from the bottom and through the track. It is designed for cases where it is desired to discharge into a bin immediately below the track and is particularly convenient for feeding reverberatory and revolving roasting furnaces, transporting crushed ore from the sulphide mill to the roaster beds, etc. These cars, like all we build, are thoroughly well made, no malleable iron fittings being used. They are made of any required size, with roller bearing wheels and foot brakes if desired, although they are usually built as shown, with one wheel pressed onto the axle, the other loose.

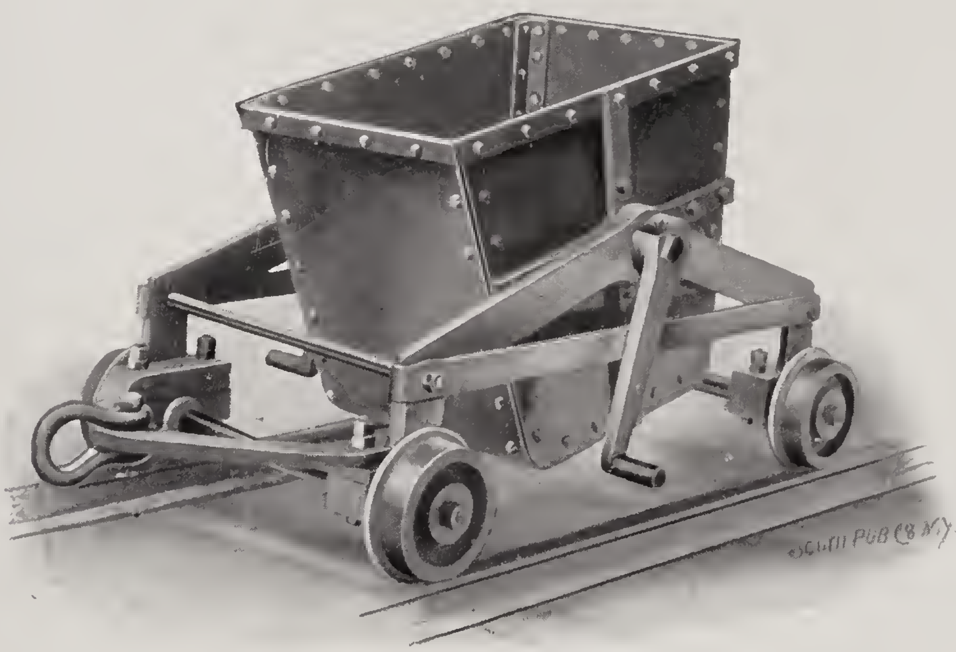


FIG. 130. AUTOMATIC DUMPING CAR.

The above car is designed especially for carrying matte, slag settlings and the various materials requiring resmelting which accumulate on the tapping floor, to the blast furnace feed floor. It is to operate on an inclined tramway, and dumps automatically by a trip at the desired point. It is made of steel throughout except the wheels and boxes, and in several sizes to meet different requirements.

Hoists.

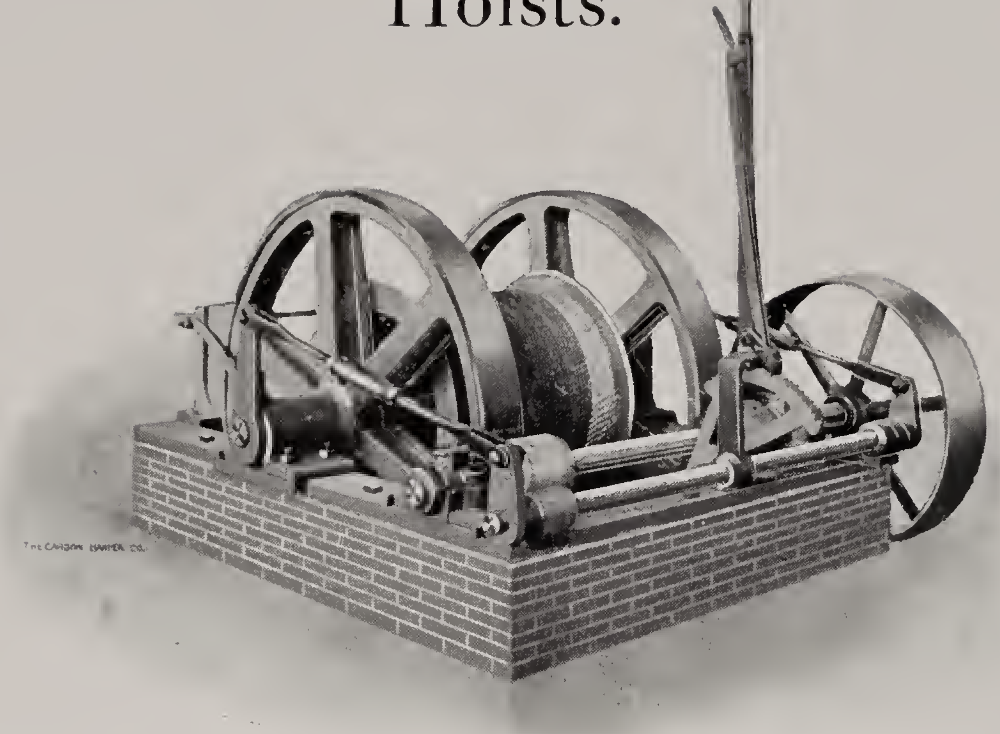


FIG. 131. DOUBLE FRICTION BELT DRIVEN HOIST.

The above illustration shows a simple and very efficient belt driven double paper friction hoist. It is used at many large lead smelters for operating the automatic dumping car shown in Fig. 130 on the inclined tramway between the tapping and feed floors. In addition to a large number sold, we have had one in very satisfactory use at our works for many years. There is nothing better for purposes of the kind mentioned.

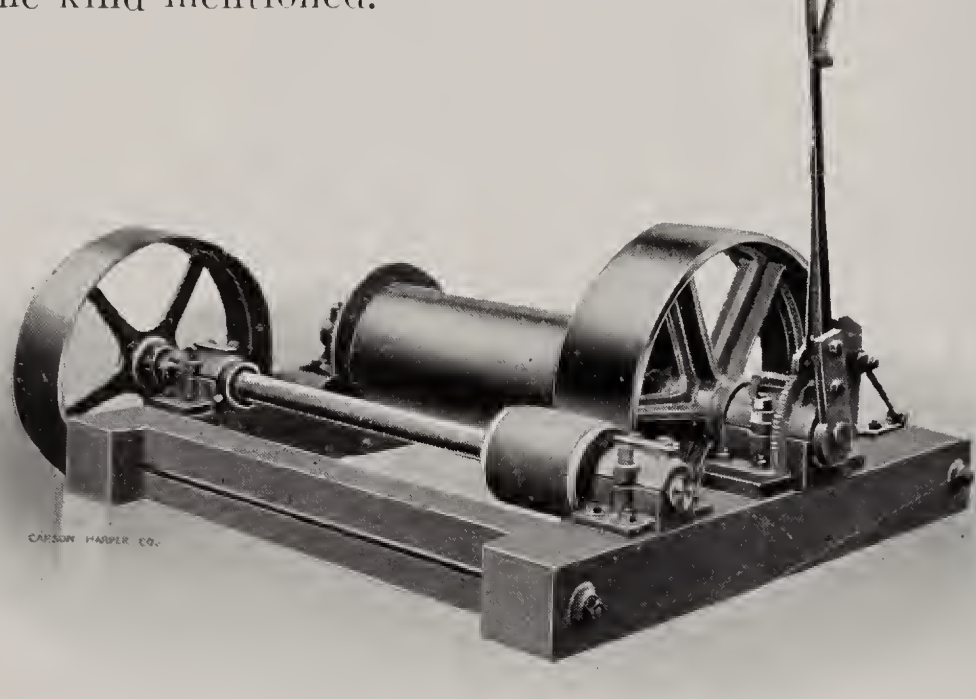


FIG. 132. SINGLE FRICTION BELT DRIVEN HOIST.

We also build a belt driven hoist with single paper friction as shown in the lower illustration on this page. Although cheaper and of less capacity than the double friction hoist, it is very satisfactory in operation.

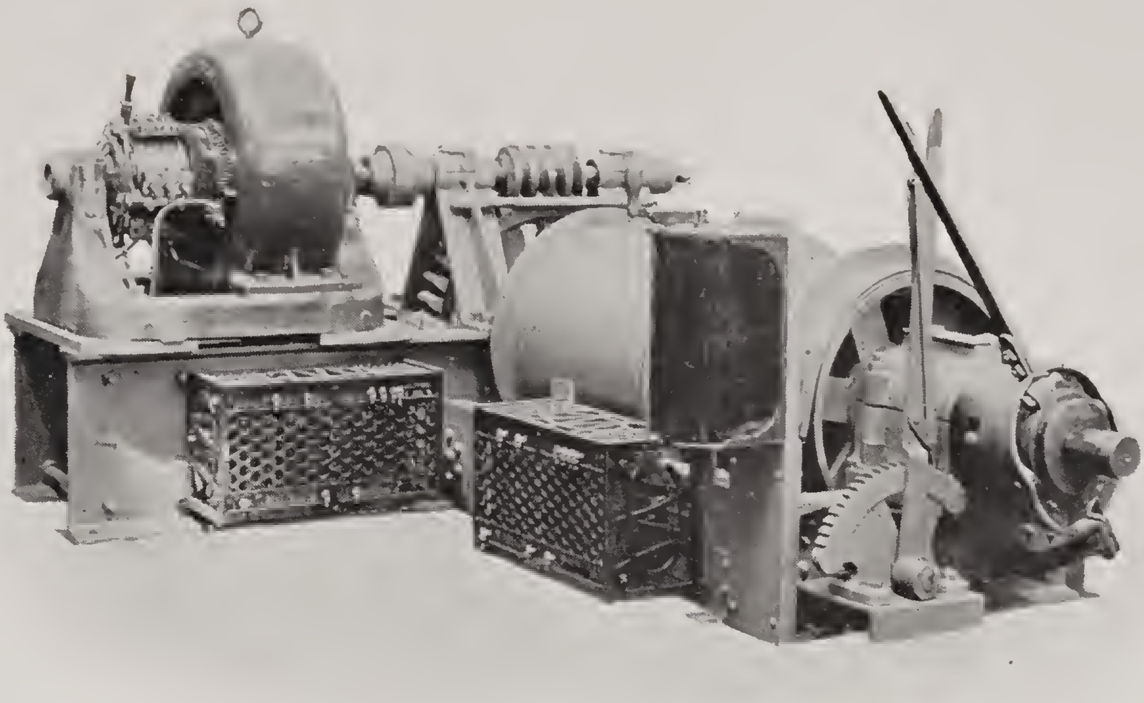


FIG. 133. SPECIAL ELECTRICALLY DRIVEN HOIST.

The above engraving shows a special electrically driven hoist for operating the matte settling system described on pages 123 and 124. The entire operation of the tramway is performed by this hoist, the raising, lowering and racking of the trolley being manipulated by the clutch lever on the end of the drum shaft, the brake lever and the electric controller. The worm is of bronze, and both it and the worm wheel have machine cut teeth.

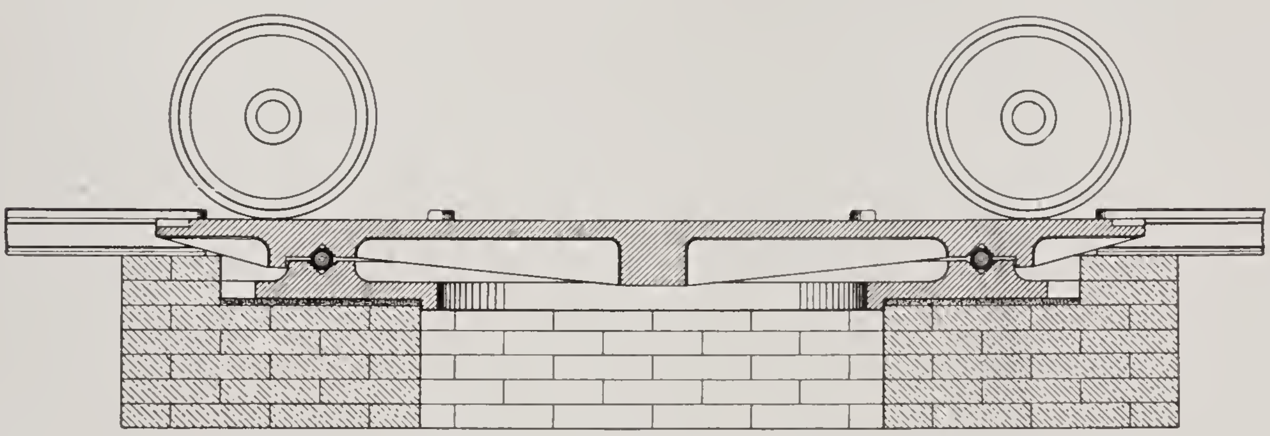


FIG. 134. BALL BEARING TURNTABLE.

The above outline drawing shows a heavy, cast-iron, ball-bearing turntable for use in turning slag trucks or other heavy loads. The top plate is well ribbed, and the ball races in both top and bottom plates are turned out, using finished and hardened steel balls, thus making an easily operated turntable. If preferred, these tables can be cast with rails on the upper face in order to avoid the wheels riding upon their flanges when passing over them. We can furnish them for any gauge of track or wheel-base centers desired.

Charging Buggies.

FIG. 135. COKE BARROW.

We show herewith a coke barrow such as usually employed. It has two wheels and is of large capacity, owing to the great bulk of coke as compared with most other material.

The charging buggy also illustrated on this page is built of ten and twelve cubic feet capacity. The bottom of the body is provided

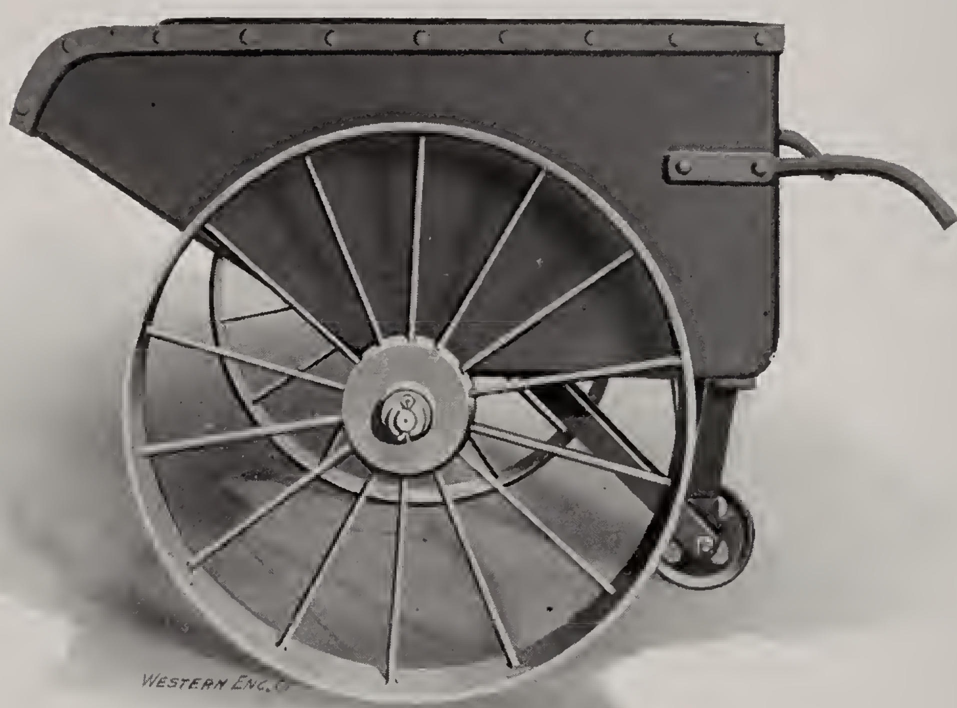


FIG. 136. FURNACE CHARGING BUGGY.

with a steel lining to take the wear from the bottom proper. The wheels are made with steel spokes of oval section, steel tires and cast iron hubs with plain or roller bearings.

Furnace Charging Scales.

We have supplied Strait scales for several years, and have been pleased with the satisfaction they have given. These makers have given great attention to details, among which may be mentioned the provision for keeping dirt from entering the scale and a special form

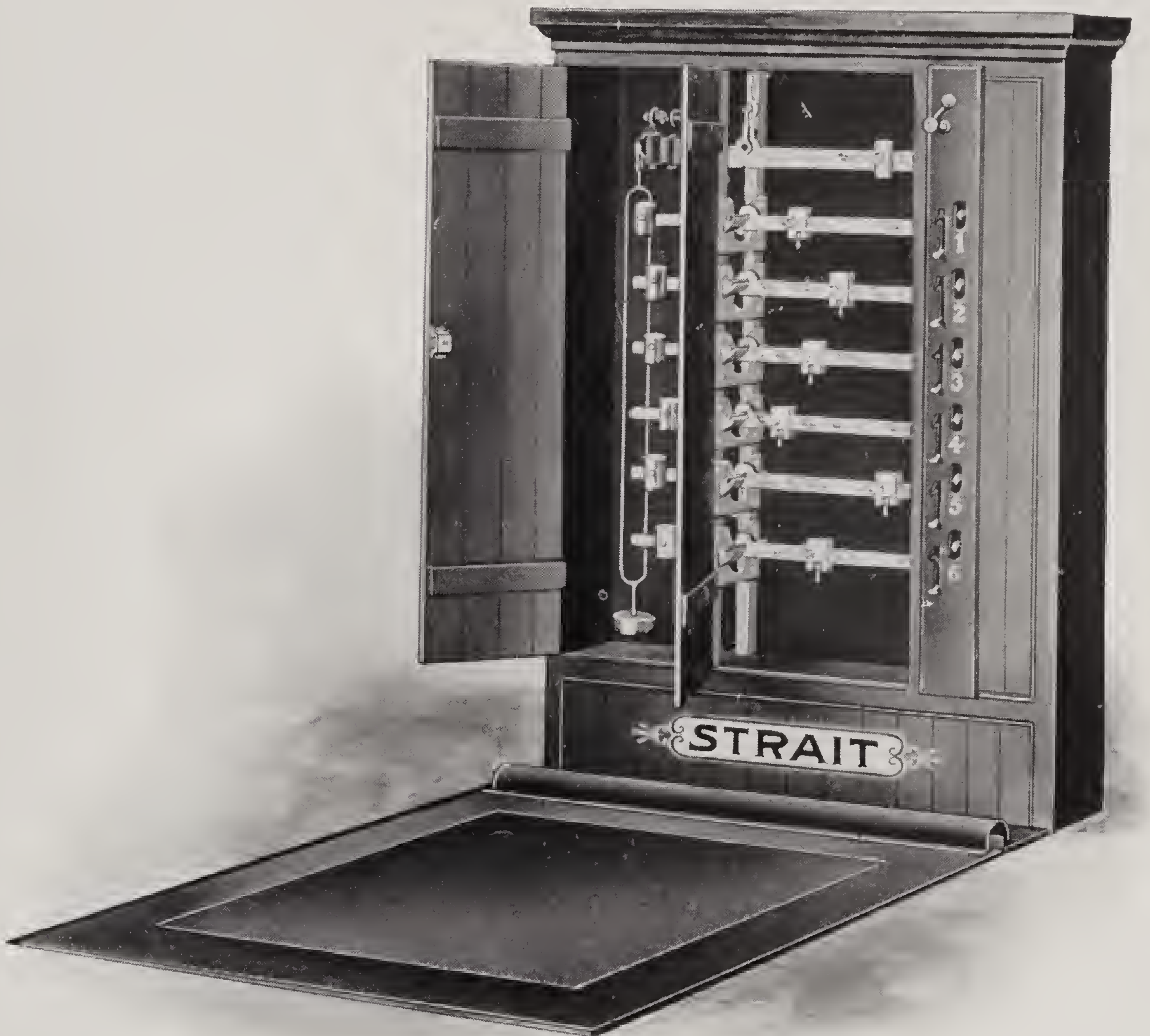


FIG. 137. MULTIPLE BEAM CHARGING SCALE.

of self-locking poise which prevents accidental change in setting by the jarring caused by travel over the platform. The frame and platform are of iron, style B, being like style A, but heavier, for weighing larger loads.

DESCRIPTION OF STRAIT CHARGING SCALES.

STYLE	Number	Number of Beams	Capacity of Each Beam	Subdivision of Beams	Size of Platform
A	450	1 to 8	1,500 lbs.	5 pounds	48-in. x 48-in.
B	452	1 to 8	2,000 lbs.	10 pounds	48-in. x 48-in.

Miscellaneous Equipment.

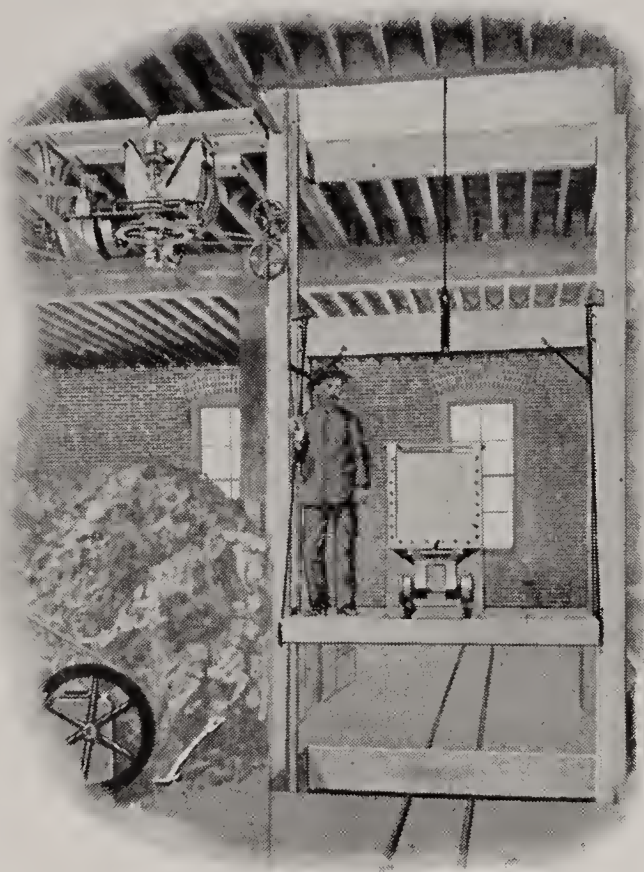


FIG. 138. PLATFORM ELEVATOR.

It is unnecessary, and indeed impossible, to illustrate or describe the various standard equipment which is used or may be profitably used in and about a smelting plant.

Platform elevators are used in some smelting plants, both lead and copper, for returning matte, foul slag, etc., to the feed floor. We furnish them of any desired capacity, with single or double platform, and to be operated by electricity, by belt from a line shaft, or by the hydraulic plunger system.

We build brakes for the operation of gravity surface tramways, which, where the grade is suitable and a straight track can be laid, offer probably the cheapest means of transporting ore. No power is required and one man at the brake can handle a large tonnage. We shall be glad to answer any inquiries on this subject.

Crushing, conveying, elevating and other equipment has been excluded from this catalogue, which is intended to be restricted to smelting; but it should be remembered that we fully cover the ore treatment field and manufacture a very extensive line.

There is much in the nature of working tools and appliances which, while strictly for smelter use, is not thought of sufficient importance to warrant its inclusion here, on account of a desire to keep the size of the book within reasonable limits. All such, including assay and laboratory equipment, we either manufacture ourselves or are in position to supply of a class suitable for the work to be performed. Likewise, machinists' tools, blacksmiths' tools and general supplies will be furnished, and we shall be glad to furnish appropriate lists of such at any time for plants of various sizes.

Automatic Samplers.

The samplers now used in the majority of the large smelters and custom samplers in the United States, Canada and Mexico are of the Vezin type, and we call special attention to the compact and self-contained features of our design. Our Vezin sampler is built entirely of iron and steel, to deliver either single or duplicate samples, cutting out either 5 per cent. or 10 per cent. of the ore passed through. They are made in two sizes, 36-inch and 48-inch, the former being suitable for ore crushed to 1½-inch cubes and finer, and the latter for ore up to 2½-inch cubes, the size depending on the size of the ore to be sampled, the capacity of either size being ample for any ordinary duty. The illustration is that of the duplicate sampler. The single sample machine differs from it only in the absence of the two chutes which cut out the extra sample.

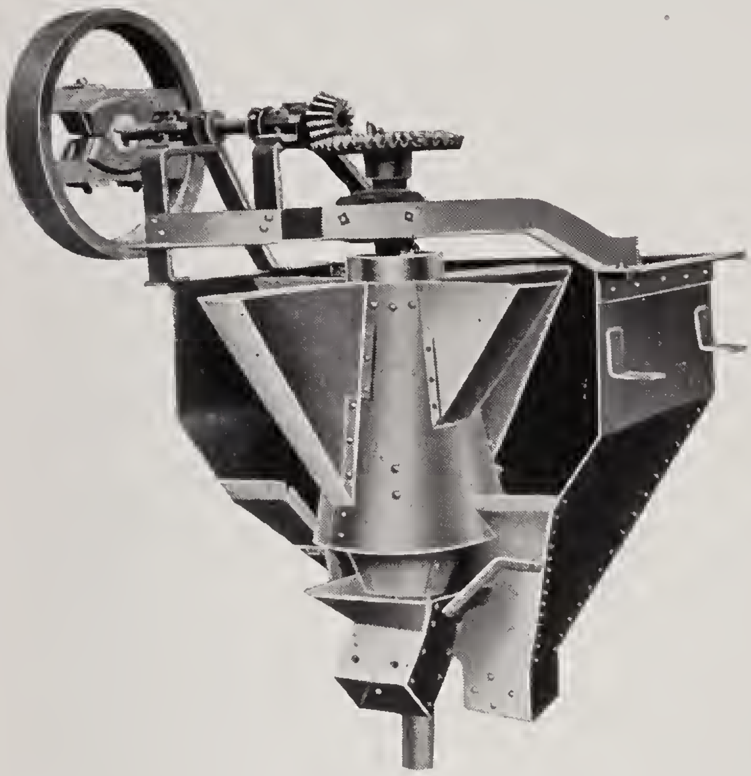


FIG. 139. IMPROVED VEZIN SAMPLER.

The Jones sampler, also here shown, is a very convenient device for laboratory use in dividing small samples of pulp. It is probably the most generally used of all the small samplers which have been offered for a like purpose, and is so simple in operation as to require no detailed description. The one shown is very substantially made of cast iron and steel and will withstand the rough usage it is liable to be subjected to. It weighs, with pans, 250 pounds.

FIG. 140. JONES SAMPLER.

Reverberatory Smelting Furnaces.

Reverberatory smelting furnaces are largely used in copper matting where the amount of fines, concentrates, etc., is so great as to make the charge unsuitable for treatment in the blast furnace. A reverberatory is also a valuable adjunct to a blast furnace smelting plant, as in addition to relieving the blast furnace of the fines and thus increasing its speed, it will also take care of the flue dust; but with a reverberatory in use there will naturally be less flue dust from the blast furnace.

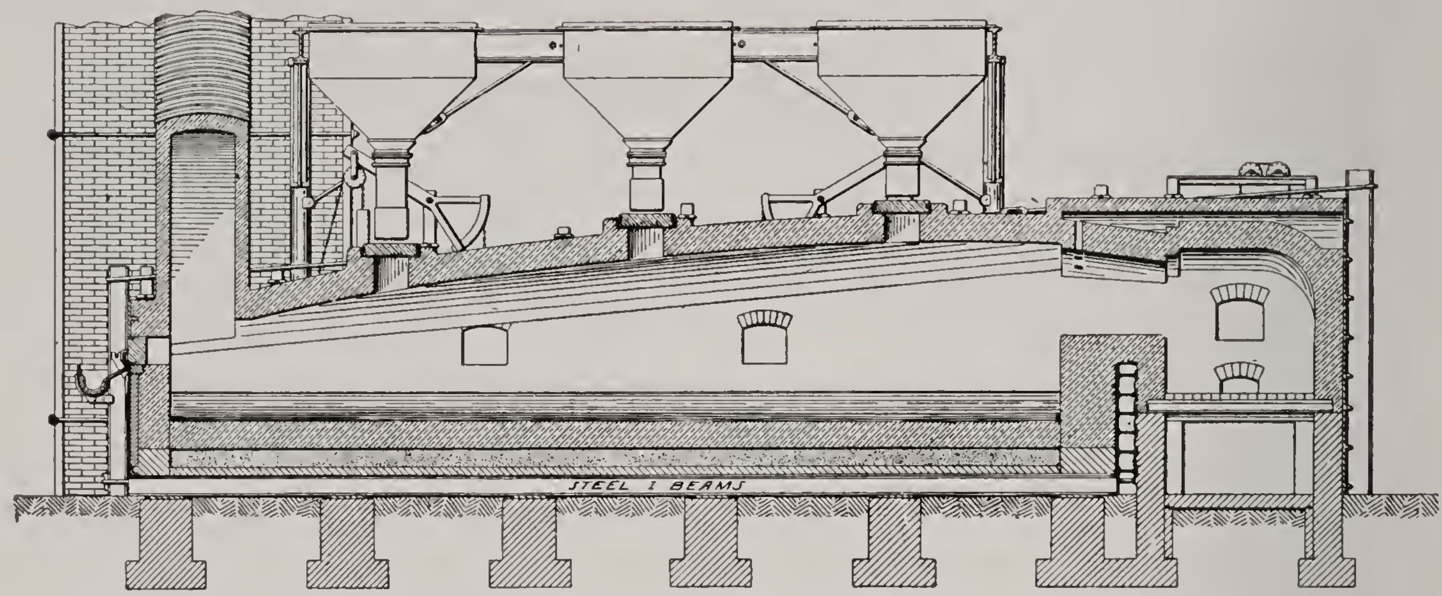


FIG. 141. REVERBERATORY COPPER MATTING FURNACE.

It does clean work, but its cost of operation is not to be compared with that of the blast furnace, except in those rare instances where the scale of operations has been very large and has been accompanied by other favorable factors. The very large reverberatories used in accomplishing these unusual results are not of general applicability, and for this reason we have chosen for illustration a furnace of moderate size, such as is suitable for use in a wider field. We are nevertheless prepared to build reverberatories of any size.

The furnace shown is one of the best construction, the entire hearth being built in a steel pan, the sides of which extend up about three feet, carried by a series of I-beams resting on low brick piers. The hearth walls to their tops, also the entire fire-box are incased in cast iron plates, thereby enclosing the entire furnace in iron and steel and preventing molten matte or slag from seeping through the walls and down into the foundation.

In very long reverberatory smelting furnaces, a deep fire-box is used, resulting in incomplete combustion and the possibility of securing the desired long flame by the admission of combustion air in the vicinity of the bridge wall.

Where fuel is expensive or of an inferior quality, it can be burned to much better advantage, both as to effectiveness and cost by first converting it into producer gas.

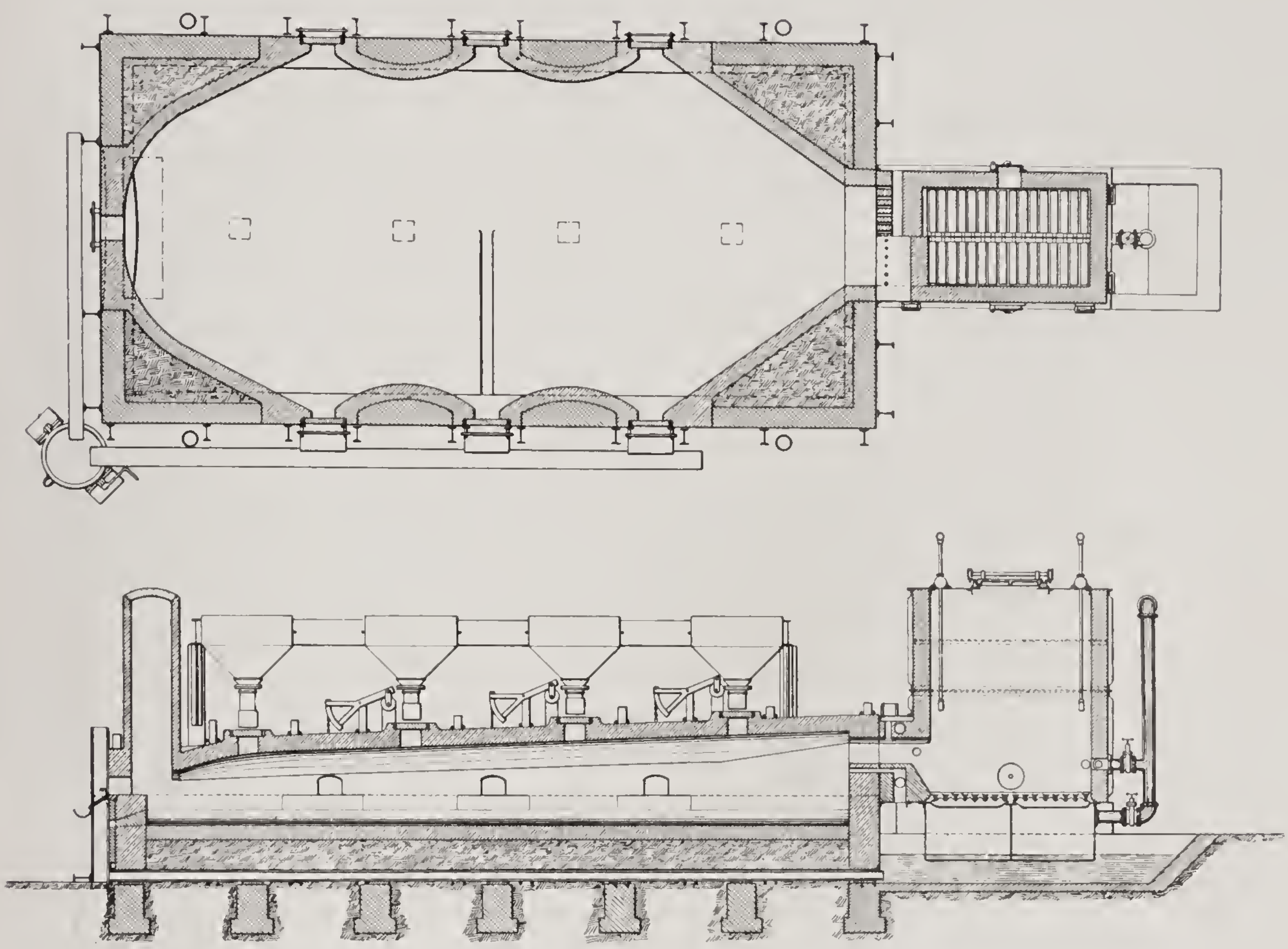


FIG. 142. REVERBERATORY COPPER MATTING FURNACE.

A separate gas producer installation introduces considerable complication, but where it is built as part of the furnace proper, these complications are avoided and the sensible heat in the gas is conserved and utilized.

Like our reverberatory smelting furnaces of the ordinary type, these are designed and constructed in the best possible manner, the interior contour being suited for the particular conditions under which they are to operate.

We supply the complete iron work for reverberatory furnaces, with drawings for their proper erection at the site of operations, and solicit correspondence concerning them.

Reverberatory Roasting Furnaces.

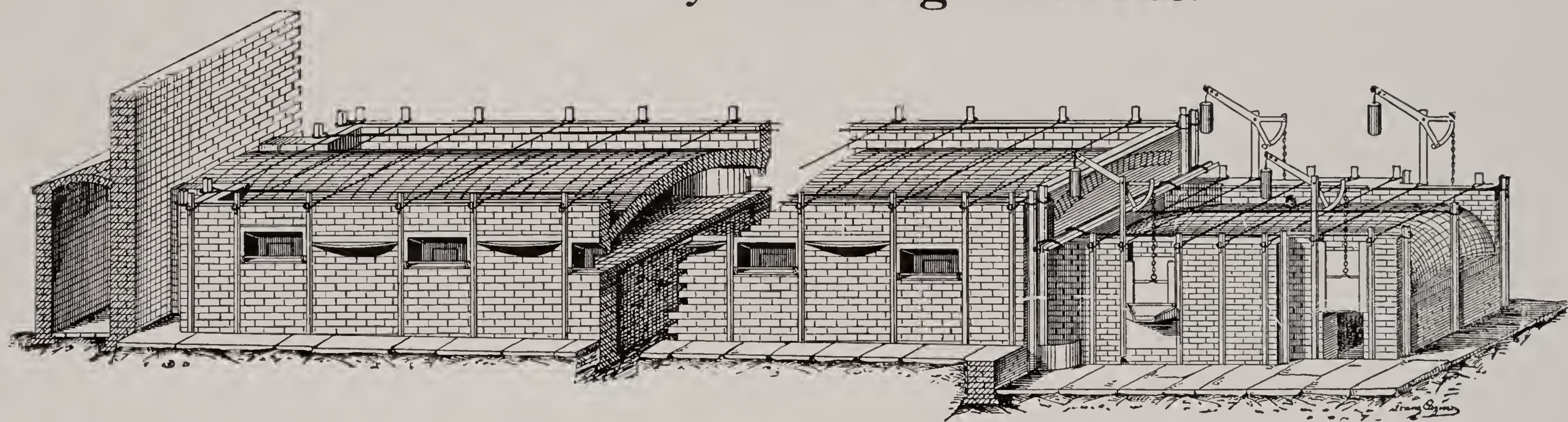


FIG. 143. 16 x 60 FT. HAND RABBLED LONG ROASTING FURNACE WITH FUSE BOX.

We show herewith a hand reverberatory roasting furnace with fusion compartment. The central portion of the roasting chamber is shown as broken away, exhibiting the construction of the interior where the ore is roasted. The ore is afterwards fused in the fusing compartment on the end to the right as shown in the cut, but where ores require roasting only before being smelted the fusion compartment is left off. The roasting compartment is the same in either case. This style of roasting furnace is a standard and is in use at nearly every lead smelter in America. The usual size is 16 x 60 feet hearth area, but conditions very often change this. We have recently built some with an 80-foot hearth, with rabbling doors spaced closer together. As custom smelters more particularly have to contend with considerable "fines," the roasted ores are slightly agglomerated by raking all calcines from the hearth of the furnace into large hand pots and tamped down, which makes quite a satisfactory product. We have complete drawings of the latest types of reverberatory roasting furnaces now in use at the large western lead smelters.

Brückner Roasting Cylinders.

The Brückner roasting cylinder is probably the most popular of all revolving roasters used in lead smelting. Our standard sizes are 6 x 12, 7 x 16, 8½ x 18, and 8½ x 26½ feet, taking charges of 3 to 4, 6 to 7, 13 to 17, and 20 to 25 tons respectively. The capacity per day depends on the percentage of sulphur in the charge and the percentage of sulphur permissible in the roasted product. The time of treatment of a charge varies from three to forty-eight hours.

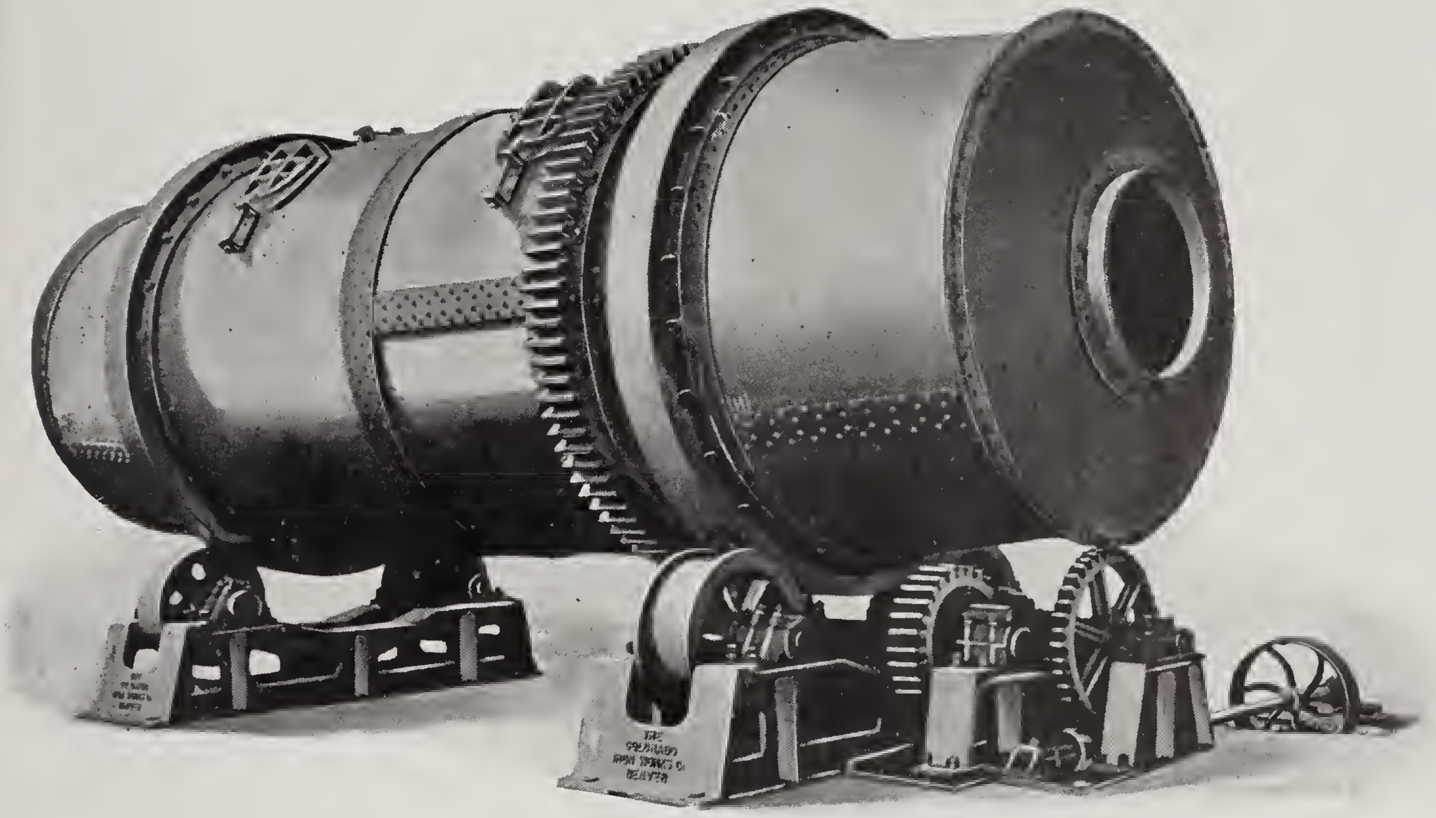


FIG. 144. 8½ x 26½ FT. BRUCKNER ROASTING CYLINDER.

The engraving is from a photograph, and shows the worm and spur gearing used to reduce the speed to one revolution in about forty minutes, to prevent excessive dust losses while turning the ore over to expose it to oxidation.

The fire-boxes, not shown, are either movable or stationary, movable when the sulphur content is high enough for roasting to proceed without extraneous heat after the charge has been ignited. The twelve-foot size has but two openings, opposite each other, one for feeding and one for discharging. The larger sizes have four openings. Charging hoppers, not shown, are furnished to be suspended over the openings, these being of a suitable size to hold one charge. Coal hoppers can also be furnished to be placed over the fire-boxes. Although we also build the White-Howell and Oxland revolving roasters, they are comparatively little used in connection with smelting.

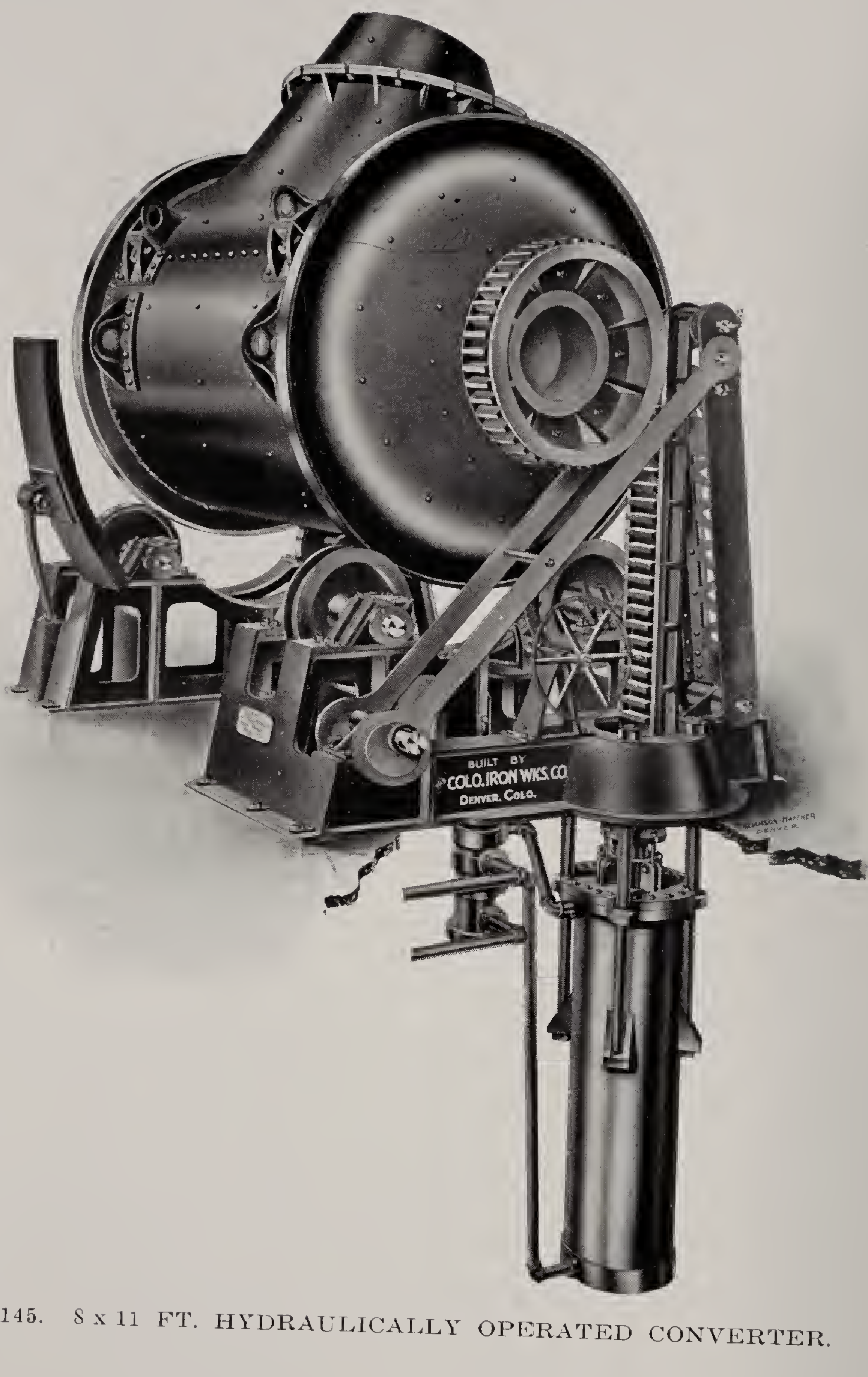


FIG. 145. 8 x 11 FT. HYDRAULICALLY OPERATED CONVERTER.

Copper Converters.

We are prepared to undertake the design and equipment of complete copper converting plants for bessemerizing copper matte. We manufacture all such, with the exception of blowing engines.

Copper converters are of two general types, the Parrot, which is barrel-shaped, placed vertically and swings on trunnions like the ordinary iron converter, and another, known as the horizontal or trough converter. The size and method of operating copper converters have progressed steadily since the first introduction of this method and converters are now the almost universal means for desulphurizing copper matte where any considerable amount is treated.

A converter plant can not be profitably operated, except on a fairly large capacity, and it is customary for smelters of moderate size to sell their matte to large plants having the equipment.

The principal methods of mechanical operation of converters are by electricity and by hydraulic power. We have chosen for illustration one of the latter, of the trough type, and desire to draw special attention to the compactness and rigidity of the stand construction. The entire operating mechanism is self-contained, the hydraulic cylinder and the cylinder controlling valve being carried by one of the sole plates. The controlling valve is operated by a large hand wheel with a toothed quadrant to which is connected the valve stem, thereby placing the range of movement of the converter shell under absolute control of the operator. The thrust of the gear on the end of the cylinder is divided uniformly between two guide rollers at the top of the guide roller stand. At the lower end of the two diagonal brace bars is provided an eccentric with which the vertical rack can readily be thrown in and out of gear. The roller-wheel boxes are adjustable by means of steel wedges. Where the details of converter construction are left to us, we build them of the best materials and in a most thorough manner throughout, as they are subjected to very severe duty and should be built accordingly.

Space does not permit the description of the various accessory apparatus and machinery which goes into the well appointed converter plant, but inquiries concerning it will be cheerfully answered.

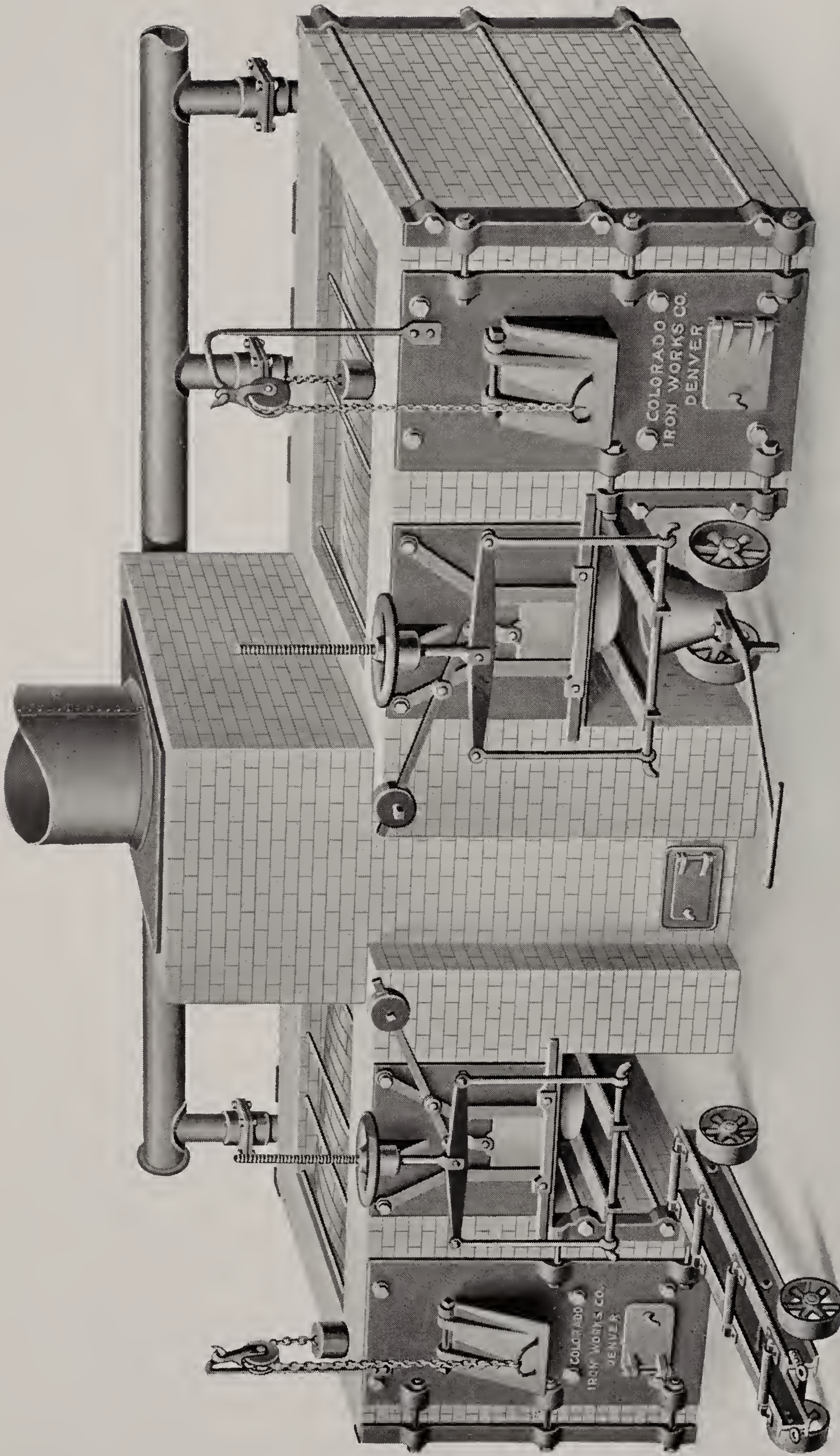


FIG. 146. DOUBLE ENGLISH CUPELLING FURNACE WITH TILTING TESTS.

Cupelling Furnaces.

In Fig. 146 we show a double English cupelling furnace with tilting test bottoms. We build them single as well as double, the construction of the single furnace being the same, except that one side is omitted. The test bottoms are supported by steel frames, the front of which can be tilted by a hand-wheel and screw conveniently located. In this form, a separate car is used for handling the tests.

Cupelling furnaces are largely used in refining lead-silver bullion, and we have also supplied them in connection with lead smelters

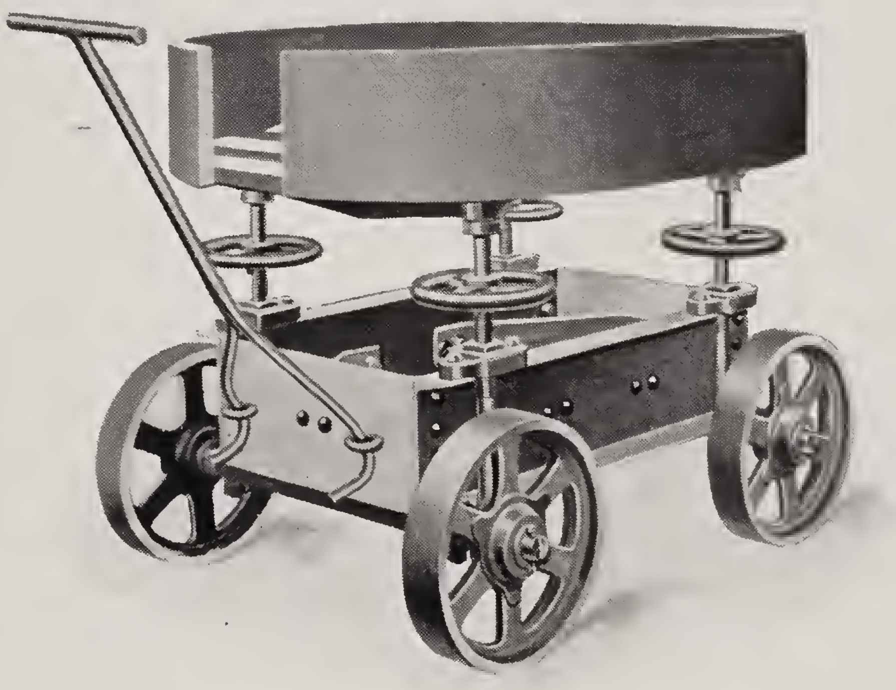


FIG. 147. CUPEL TEST CARRIAGE WITH 36″ x 48″ TEST RING.

where there was a deficiency of lead for the blast furnace charge. They are then operated for the production of litharge, but the concentration of the bullion into a more valuable shipping product is also of advantage.

In Fig. 147 we show another form of test carriage with an ordinary test ring. In this form the carriage remains in position and the four independent screws at the corners insure a close fit between the test and the compass ring. The plain test ring is used where the corrosive action of the litharge does not destroy the filling with sufficient rapidity to justify the inconvenience of maintaining a circulation of water in a jacketed test ring, although there are many cases in which jacketed test rings are found preferable on account of the prolonged life of the filling.

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